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The Magazine of New Energy Technology

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Volume 8 • Issue 46 • 2002

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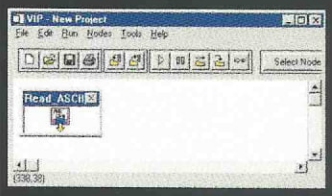

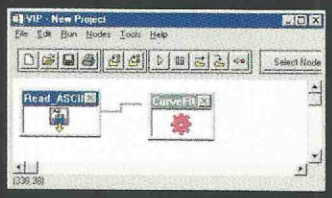

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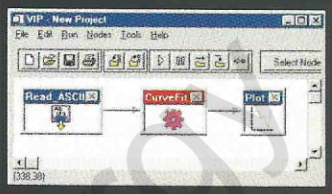

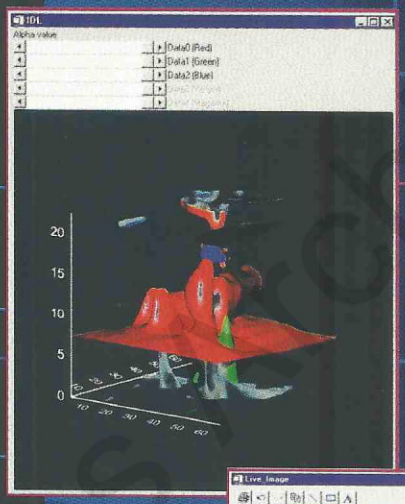

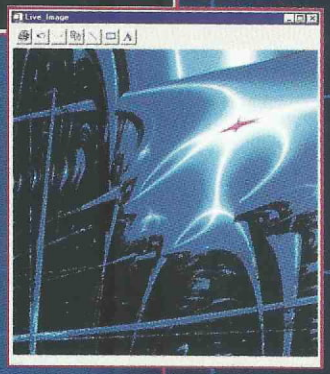

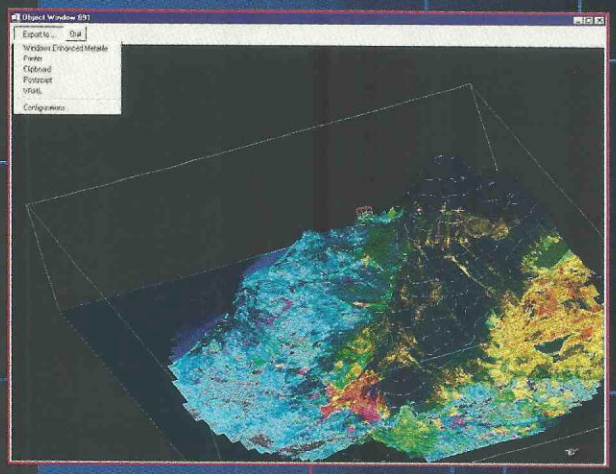

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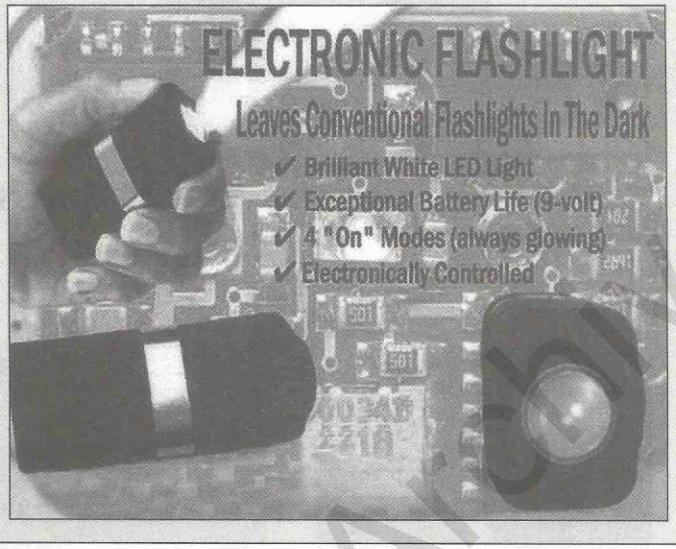

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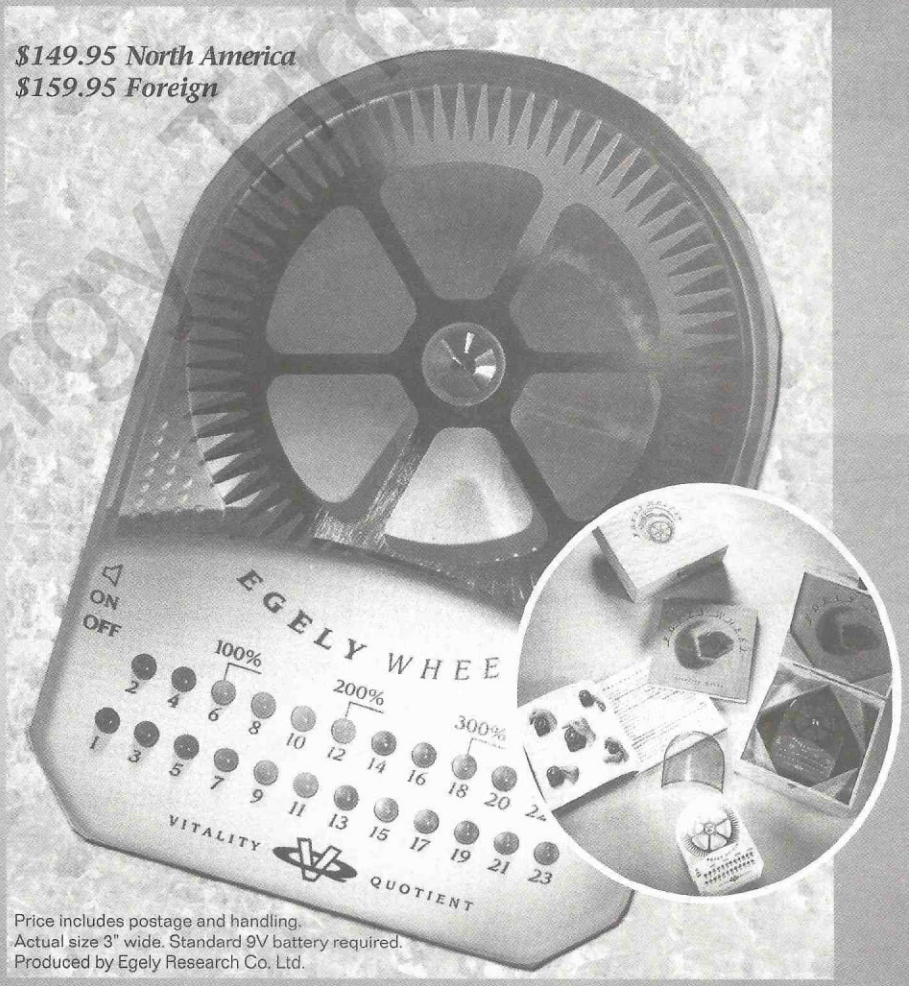

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The Big Bang Theory is Busted

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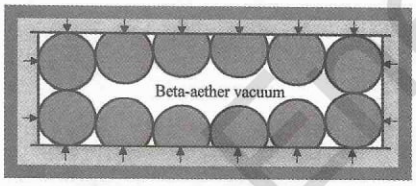

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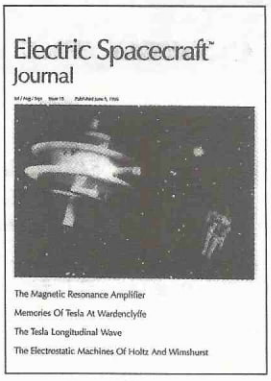

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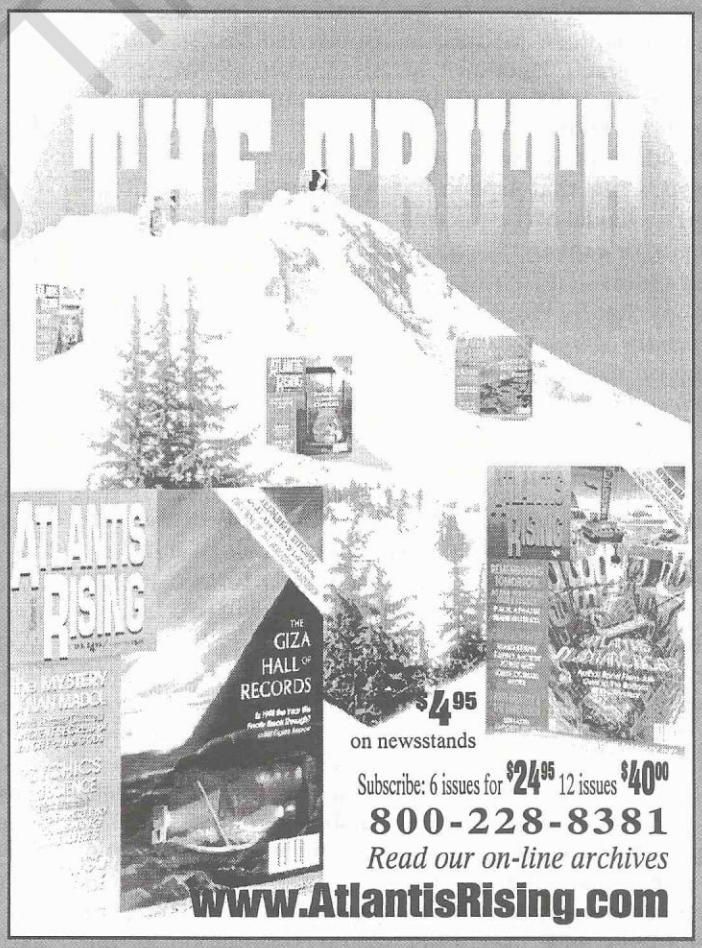

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LETTERS TO THE EDITOR

The Nature of Aether

Congratulations indeed for having published D.L. Hotson's paper on Dirac's theory (*IE* #43, #44), T.E. Phipps' comments (*IE* #45), and the author's replies (*IE* #45). We would like to suggest that both are right and wrong. A hole with mass, charge, and spin is an oxymoron, but that is indeed the basis on which Dirac's theory arose; yet, in terms of a correct understanding of mechanics, we would hardly be better off if Dirac's idea had been given an honest try, instead of the intellectual heirs of Claudius Ptolemy having monopolized the game. Why? Because, as Phipps says, it is a matter of simplicity—but simplicity that "works" (hence Ockham). Now, Dirac's theory is a patent instance of a simplicity that does not work—neither mechanically nor energetically. Massbound leptonic charges are not point charges (try to obtain mechanical effects from point collisions. . .if a charge is concentrated at a point, the spacing of its constituents will be żero); they do not display positive and negative mass according to whether their charge is negative or positive; there is no need to confuse the kinetic energy of a lepton with its mass-energy; nor to fall into the obvious problem of making the energy of the electron infinite—just in order to hold onto Maxwell's theory; and Dirac failed to propose a cogent process for the formation of asymmetrically charged lattices. All this, as Aspden has written in the chapter "Dirac's Electron" of his *Modern Aether Science* (www.energyscience.co.uk), in order "to avoid the unnecessary complication of not having the field equations Dirac uses 'holding all the way up to the electron's centre'" (p. 95).

Yes, it is true that Aspden has overcome all these difficulties with a model of the electron that obeys the classical configuration of a sphere. We have proposed a different model—that of a torus—and a host of new functions, including wave functions that by Phipps' criterion can only be described as "beautifully simple" (www.aetherometry.com). This has a bearing on the David Bergman essay you also published in *IE* #45, and in particular on Parson's 1915 spinning ring model—specifically what is wrong and right about it. We have published some of this material already (see our LS-25 and AS2-12 reports, in particular), and more detailed publications are forthcoming on the same subject. We have, furthermore, formally demonstrated how cosmological lattices of electrons can be and are asymmetrically formed in balance with aether energy (defined as massfree energy, whether in electric or nonelectric form), and how this mechanism is responsible for the microwave cosmic background radiation (CBR). Few physicists have paid attention to our work, but we think they should—given that many of their questions have already been answered. Indeed, aether energy is not composed either of a sea of negative-energy electrons or of any other form of massbound charges; aether energy is massfree energy having its own laws of motion and wave superimposition. Electron lattices and their inertial and kinetic properties are always second to the presence of aether energy and, specifically, to the contribution by the "vacuum state" of massfree electric radiation (ambipolar radiation). Dirac's theory is fantastic precisely because it takes recourse to fictions that are susceptible neither to a mechanical nor to an energetic treatment. As Aspden correctly saw, physicists—and Dirac—were so convinced that electrons must radiate when accelerated (Schott called it a direct consequence of a mechanical theory of the aether) that they missed the fact that when accelerated the electron radiates no energy at all. It is only when decelerated or stopped that it does—by shedding its kinetic energy and conserving its mass-energy. Once the difference between the mass-energy and kinetic energy became blurred, it would appear that the electron had no boundary and extended into infinity. With such nonsense, it is little wonder that the nature of the aether has remained impenetrable to the best of physicists. It took our work to actually identify the process whereby shed kinetic energy gives rise to locally produced photon radiation. Maybe Hotson and Phipps should look into this.

Paulo Correa and Alexandra Correa
Concord, Ontario, Canada

Pulsed Water Arc Explosions

In response to Professor Bockris' letter in *IE* #43, we would like to point out that in our pulsed water arc explosions, as described for example in *IE* #33 ("Solar-Energy Liberation from Water by Electric Arcs), the energy supplied by capacitors to the arc raised the average water temperature by only a few degrees. This is insufficient to generate steam or dissociate a significant amount of water. Nevertheless, we believe it is possible, and indeed likely, that the arc produced some cold fusion reactions.

Readers may be interested in some unpublished results obtained in 1995/1996 in the Hathaway Laboratory in Toronto with arc explosions in heavy water. The heavy water did in fact increase the measured fog momentum of the explosions by approximately 10%. However, this was deemed insufficient to override the earlier conclusion that the bulk of the energy liberated in the cold fog explosions must be of chemical origin. The Toronto experiment does not exclude a minor contribution to the explosion from nuclear energy.

Prior to the heavy water experiment, we researched and reviewed many papers published on filamentary arc explosion experiments, which all revealed fusion reactions accompanied by neutron emission. The striking feature of these experiments (performed at Berkeley, Harwell, Los Alamos, Imperial College, and many other laboratories around the world) was that the neutrons were not emitted isotropically in all directions, as in thermonuclear processes, but they strictly traveled parallel and in line with the arc axis. This is only possible if the D-D collisions are axial col-

New Energy Times Archive

lisions. We argue that Ampere tension in the fusion filaments is the electrodynamic cause of these cold fusion reactions.

Our earlier wire arc explosions required the same type of electrodynamic force system in solid metal. In liquids and gasses, these longitudinal Ampere forces will produce axial collisions of deuteron ions which seem to be of adequate strength to produce cold fusion.

These findings have been published in a number of papers and reviewed in our book *Newtonian Electrodynamics* (World Scientific, 1996). The vast majority of physicists are not familiar with the Newtonian longitudinal Ampere stresses and are therefore at a loss to explain their cold fusion results.

Peter Graneau, Concord, Massachusetts
George Hathaway, Toronto, Canada
Neal Graneau, Oxford, England

Using Beryllium

Although I suggest this experiment with some ambivalence, it should not be too difficult to do, and a positive result would *prove* the existence of cold fusion.

Consider a reaction vessel operating under conditions where excess heat is being generated. Measure the presence (or absence) of neutron flux. Insert a small piece of beryllium metal into the vessel near the cathode. Measure the neutron flux again. Any increase of the flux would prove that energetic alpha particles are being generated in the vessel, which in turn proves the existence of cold fusion. The reaction involved is

$$^{4}Be^{9} + {}^{2}He^{4} \rightarrow {}^{6}C^{12} + n + 5.70 \text{ MeV}.$$

Of course, this reaction would enhance the excess heat. It would also enhance the catalytic reaction of $^{3}Li^{6}$ and $^{1}H^{2}$ mentioned in my paper in *IE* #43 ("Enhancement of Cold Fusion Processes in Palladium by Catalytic Agents").

$$^{3}Li^{6} + n \rightarrow {}^{1}H^{3} + {}^{2}He^{4} + 4.78 \text{ MeV}$$
$$^{1}H^{2} + {}^{1}H^{3} \rightarrow n + {}^{2}He^{4} + 17.50 \text{ MeV}.$$

Fermi used beryllium to generate neutrons in his experiments in Rome in the 1930s. His source of energetic alpha particles was a vial of radon gas.

My ambivalence results from the fact that both neutrons and beryllium can kill. Beryllium dust must be avoided.

Robert Parmenter
Tucson, Arizona

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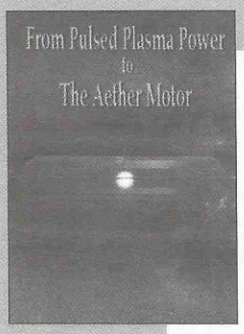

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UPCOMING EVENTS

ICCF10 Scheduled for 2003

The 10th International Conference on Cold Fusion has been scheduled for August 24-29, 2003, at the Royal Sonesta Hotel in Cambridge, MA.

Visit http://iccf10.org for detailed information as it becomes available.

Errata

We received the following communication from Dr. Travis Taylor of Huntsville, Alabama, regarding Tim Ventura's article in *IE #45* ("The Evolution of Lifter Technology"):

"Tim Ventura's article states: 'Art Bell did the honorable thing by sending them (the alleged UFO parts) to an acquaintance in U.S. Army research, Travis Taylor, for professional scientific investigation.' This is wrong! I had never heard of Art Bell or his radio show and I was definitely not his acquaintance! I still have never met him and only talked to him once on the phone. My involvement was very innocent and accidental. The article suggests that I '. . .apparently tested the materials after-hours in a world-class research lab to avoid potential classification by his superiors. . .' This statement implies that I did something in a clandestine fashion and did not follow proper authority and security channels—not true!

"Here is what really happened: I went to my boss and then to his boss and they simply said for me to do it on my own time because that was not my job description at the time. They welcomed those types of research efforts and they both warned me about possible career-destroying publicity. Also, just to make sure that I was not stepping on any other department's toes, I contacted the Defense Intelligence Agency through our local security and alerted them to my efforts. They had no problems with the project either and there were never any security guidance issues!

"Incidentally, I met Jeff Cameron years ago. Both of us have been in the Huntsville, Alabama laser research community for some time. Both of us agree that the 'lifter' effects that I have seen were most likely whatever the Biefeld-Brown effects are. Jeff has some practical application theories about leakage currents and so on. I myself do not believe that the 'ion wind' explanation works. I have my own theory, based on General Relativity, but that is a longer story for another time."

We thank Dr. Taylor for this clarification and comment. We regret that his actions were incorrectly described, albeit inadvertently so, by author Tim Ventura.

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A New Era Begins. . .

New Energy Foundation, Inc.

With this, the 46th issue of *Infinite Energy* magazine, new opportunities begin for new energy and new science. Those many subscribers and regular readers who have appreciated this pioneering publication will be happy to learn that we have taken a dramatic step to insure *Infinite Energy's* longevity. A new corporation, New Energy Foundation, Inc. (NEF), has been formed in the State of New Hampshire, and ownership of *Infinite Energy* has been transferred to that not-for-profit corporation. Indeed, financial contributions to NEF (above and beyond the regular subscription price or cost of merchandise) will henceforth be tax-deductible.

NEF's expected 501c3 public charity status is anticipated to be awarded by the IRS in the coming several weeks. As soon as possible, we will provide you with the information required to make secure, tax-deductible contributions of cash, securities, real estate, or other financial instruments. We hope that you will all consider becoming charitable contributors—even if at a modest level. Please understand that the current subscription and newsstand prices of *Infinite Energy* are less than 30% of what it costs to carry on a publication of this quality at the frontiers of knowledge—for which no significant advertising base yet exists, and which is the recipient of mockery or neglect by most of the scientific and media establishments.

Launching the New Energy Foundation is significant for two basic reasons:

• *Infinite Energy* will now be better able to attract financial support from a broader group of concerned citizens and well-wishers, rather than relying on the several backers who have helped the magazine in the past, some of whom will continue to support the magazine generously.

• We will be able to raise significant funds to provide much-needed scientific research and development grants to hard-pressed new energy researchers. [Please take note of the requirements to apply for such grants, soon to be posted at www.infinite-energy.com.]

Apart from continuing to subscribe to *Infinite Energy*—and encouraging others to do so too—we hope that *you* will be able to contribute generously to New Energy Foundation, Inc. A New Hampshire-based, distinguished Board of Directors is now in place to help guide the New Energy Foundation with its flagship publication, *Infinite Energy*, but also with the equally important new task of raising research money to help push new energy forward.

Here is the basic concept: It has been far too difficult to persuade venture capital to invest in new energy technology that is not quite ready yet for "prime time," so we will break the vicious Catch-22. We will appeal to the humanitarian and charitable instincts of those in a position to ***invest charitably*** in the most fundamental aspect of our future: The triumph of truth over falsehood on the frontiers of science—in which the new energy field, in our view, will be the first triumphant, paradigm-shattering example.

As most of you already realize, there is almost no area of human activity that would not be dramatically affected by the advent of new energy technology—especially matters of war or peace and health and the environment. Therefore, providing tax-deductible support to the New Energy Foundation should be thought of as a significant investment in *your* future and that of your loved ones. ***If you doubt this, just try to imagine our world ten, twenty, or fifty years hence without the advent of a dramatic source of new energy such as cold fusion (low-energy nuclear reactions), aether energy (or zero-point energy/space energy, if you prefer), or some other very powerful new physics energy source!*** It's not a pretty picture. Frankly, what we have today in the menace of hydrocarbon fuels and an associated geopolitical nightmare is very ugly indeed. Furthermore, a future of abundant, clean energy has almost zero chance of emerging from the well-intentioned, beneficial, but limited world of wind-power, photovoltaics, and other *conventional* renewables—not to mention from the so-called controlled *hot* fusion program, which is lavishly funded by governments to the exclusion of new energy.

As Editor-in-Chief of *Infinite Energy*, and now also the President of the New Energy Foundation, I hope that I may have your generous support and confidence in my judgments and those of colleagues on the NEF Board, which will always be supported by consulting with a host of scientists and leaders in the new energy field.

Very Best Wishes for a New Energy Future,
Dr. Eugene F. Mallove
President, New Energy Foundation, Inc.

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The Implications of the "Big Bang"

by Eugene F. Mallove, Sc.D.

A long time ago, in a life before cold fusion and new energy, I published a book, *The Quickening Universe: Cosmic Evolution and Human Destiny* (1987), a portrait of our universe as I then understood it. This, my first book, was based on the collected wisdom of the cosmologists and biologists whom I had studied and believed. I now reject that tidy picture, which rested on what I then thought was a sound theoretical framework underlying the basic "Big Bang" cosmology, one based on multiple interlocking streams of experimental evidence. I am still proud of my synthesis of those days, so we still distribute *The Quickening Universe*, but with the following caveat affixed to the inner cover. This is evidence of a capacity to evolve, to move on:

> Dear Reader:
>
> Any author of a "cosmological philosophy" such as *The Quickening Universe* is duty-bound to re-evaluate his reflections and former "certainties" in light of new information. As you will read in the Preface to this 1987 work, I wondered ". . .what the volume's sequel would reveal if I were fortunate enough to be able to set it down in 2010." It is not quite 2000 as I write this introductory note, but already I can say that there is so very much that I did not know in 1987 that would now have to be incorporated into a 2010 edition.
>
> First, the low-energy nuclear reaction revolution (a.k.a. "cold fusion") that emerged in 1989 and thereafter, in which I became deeply involved as a writer and researcher (*e.g. Fire from Ice: Searching for the Truth Behind the Cold Fusion Furor*, 1991), was totally unexpected. The results to date potentially change scientific conclusions in virtually every field—including biology, but especially physics and chemistry. Second, in view of my learning first-hand about the astonishing resistance of the scientific establishment to radically new phenomena that have been conclusively demonstrated in the laboratory, I have been moved to explore other heated controversies in science in which paradigm paralysis may have played a role. I conclude that there is a huge area of possible scientific revisionism that would have to be applied to the edition of 2000, let alone that of 2010!
>
> However, since a complete rewrite for 2000 was not in the cards, let me say that I am very proud of my synthesis of diverse branches of human knowledge in 1987. I still hold to a model of a universe coming to life—quickening—as a forced process from the basic physical "laws." What those physical laws really are and what has been their history of operation in this and other parts of the universe is much less clear and certain to me in 1999 than it was in 1987. And, I am no longer sure that these "laws" have much to say about proscribing certain transcendent phenomena that are glimpsed in the laboratory even today [Note: I was thinking of the work of Prof. Jahn and others at Princeton.—EFM]. I believe that I was then a 40 year old child who has grown up. I apologize for some of the excess-certainty and dogmatism that you will find on these pages, but please do enjoy your tour through *The Quickening Universe*. Learn about what you may yet become.
>
> —Dr. Eugene F. Mallove (July, 1999)

I have come to realize that there are many reasons to reject the Big Bang, almost all having to do with the manner in which the physics community misrepresents fundamental data, which it claims supports the Big Bang. That misrepresentation is identical in character with its single-minded certainty, to cite one prominent example, that low-energy nuclear reactions (LENR) are impossible and that all data seeming to support LENR must be rejected. We are honored to be able to publish astronomer Dr. Tom Van Flandern's annotated list of reasons to reject the Big Bang (p. 10). He draws the following conclusions, with which I agree:

> The Big Bang, much like the Santa Claus hypothesis, no longer makes testable predictions wherein proponents agree that a failure would falsify the hypothesis. Instead, the theory is continually amended to account for all new, unexpected discoveries. Indeed, many young scientists now think of this as a normal process in science! They forget, or were never taught, that a model has value only when it can predict new things that differentiate the model from chance and from other models before the new things are discovered. Explanations of new things are supposed to flow from the basic theory itself with, at most, an adjustable parameter or two, and not from add-on bits of new theory. . .Perhaps never in the history of science has so much quality evidence accumulated against a model so widely accepted within a field. Even the most basic elements of the theory—the expansion of the universe and the fireball remnant radiation—remain interpretations with credible alternative explanations. One must wonder why, in this circumstance, four good alternative models are not even being comparatively discussed by most astronomers.

To glimpse how solidly the current Big Bang view is accepted by the mainstream, let me quote Princeton University cosmologist P. James E. Peebles, in his introduc-

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tion to *Scientific American's* "Special Edition: The Once and Future COSMOS" (2002, on newsstands until 2003). After a brief overview of "evidence," which supposedly supports the Big Bang, he writes: "I compare the process of establishing such compelling results, in cosmology or any other science, to the assembly of a framework. We seek to reinforce each piece of evidence by adding cross-bracing from diverse measurements. Our framework for the expansion of the universe is braced tightly enough to be solid. The big bang theory is no longer seriously questioned; it fits together too well. Even the most radical alternative—the latest incarnation of the steady state theory—does not dispute that the universe is expanding and cooling. You still hear differences of opinion in cosmology, to be sure, but they concern additions to the solid part."

It seems that Dr. Peebles has cross-braced himself right into a tight paradigm box from which he cannot escape! And, he marginalizes the best critics of the Big Bang, such as astronomer Halton Arp, Tom Van Flandern, and others, by failing to mention that they even exist. Only "differences of opinion" on the details of the Big Bang are allowed. This is analogous to a hot fusion researcher claiming that only "differences of opinion" exist on how to build the next hot fusion reactor experiment, while ignoring that a fundamentally different approach to generating fusion-scale energy from hydrogen, LENR (a.k.a. "cold fusion'), has been discovered and proved. The most significant implication to be gathered from the ascendancy of the Big Bang—some have called it the "cult of the Big Bang"—is that the *process* of science has broken down, particularly within physics.

We need not review all the reasons to reject the Big Bang—we leave that to Dr. Van Flandern and others—beyond mentioning that many early twentieth century and present explanations for the cosmic background radiation exist that have nothing to do with a Big Bang, that photographic and radio telescope evidence exists to challenge the very basis of the expanding universe (the interpretation of galactic redshift as cosmic expansion), or that cosmic light element distribution data have literally been *fudged* into agreeing with an early hot universe Big Bang theory. That's enough!

Yet, one idea that Big Bang cosmologists propose must indeed be correct, but not in the manner that they think. It is well-known that contemporary Big Bang cosmology requires *an intimate blending of the microcosm of particle physics and fundamental forces with the features of the macrocosm*—the present universe of galaxies, quasars, radiation, and whatever else ("dark matter," "dark energy," "quintessence,"?). How did these particles and forces, as conceptualized by the mainstream, emerge from that hot, concentrated early universe—at the supposed origin of "spacetime" itself from a microscopic "singularity" of some kind?

Alternative cosmologies that view the universe being perhaps infinitely old—with no beginning and probably no end—must deal as well with the origin and destruction of particles of matter, in whatever cataclysmic or benign processes may be hypothesized. This process of creation and destruction may be occurring everywhere in the universe in processes that have heretofore escaped our notice, and/or at particular sites of violent cosmic eruptions, such as from within the cores of galaxies. And, if besides matter and radiation there should be a cosmic fine-structured aether associated with space and time (whatever its physics), there must be a physics for the origin and evolution of mass-bound particles from that aether. The only other generic alternative to aether-emerging particles (apart from the Big Bang), is that they were created *de novo*, perhaps by some transcendent power (God), as many may wish to believe. I should hasten to add that a liberal interpretation of the biblical *Genesis* story of the Judeo-Christian tradition need *not* depend on Big Bang cosmology. It is abundantly clear that our Sun and its planetary system had to have had a multi-billion-year process of origin from a cosmic plenum of some kind.

The implications for new energy science and technology of non-Big Bang cosmology are profound, which is precisely why studying the arguments for and against the Big Bang is so important. Cosmology is not merely a luxury to understand our ultimate origins, so that we may be either philosophically or emotionally pleased or displeased! If we view the present condition of matter as winding-down—decaying toward some ultimate oblivion, as the Big Bang would have one believe—we are forced to conceptualize matter in the way that the so-called Standard Model of elementary particles and forces allows. This model, I am reasonably convinced, does not even allow for the kinds of evidence that is being found today in LENR experiments, not to mention even more provocative devices and tests that imply an extraction of energy from the plenum of space itself (aether or "ZPE"). And, the Standard Model, with Special and General Relativity as its conceptual framework, does not seem to have even a clue about the true nature of gravity.

So, what cosmology and physics could replace the Big Bang? That is a tall order, demanding enough that it should be left perhaps to a far future issue of *Infinite Energy*. But it would be unfair, in closing, not to characterize some of the non-Big Bang cosmological models that have been put forth:

• ***Quasi-Steady State Cosmology*** (F. Hoyle, G. Burbidge, J.V. Narlikar, 2000): Creation of new matter occurs in "little bangs" (or "mini-creation events") in the cores of galaxies—matter that is ejected from galactic nuclei as quasars. The universe is infinitely old.

• ***Plasma Cosmology*** (E.J. Lerner, 1991): An infinite universe evolving over infinite time, with dominating electromagnetic effects of interacting plasmas (rather than gravitation) forming galactic and large-scale structures.

• ***Meta Model Cosmology*** (T. Van Flandern, 1999): "A new cosmological model of the universe, arrived at deductively, in which the universe is infinite in five dimensions and filled with substance at all scales. In it, gravitation produces the redshift of galaxies, is limited in range, and is produced by the pushing action of tiny agents on matter."

• ***Variable Mass Cosmology*** (H. Arp, 1998): A non-expanding universe that is indefinitely large and indefinitely old. "Objects are continually being born and are growing, but are somewhat different in each generation." High red-shifted objects are young because they are born of newly created matter in which particles, such as electrons, have very low mass, which increases with time.

• ***Universe Cycle Model*** (A. Gulko, 1980s): Each galaxy undergoes separately a cyclic process of birth, growth, aging, death, and rebirth within an infinite universe. Quasars are stages of galactic evolution prior to formation of a normal galaxy.

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• ***Aetherometric Model*** (P. Correa and A. Correa, 2002—partially published): The universe is infinitely old; time and space manifolds are separate. The spectrum of a microwave cosmic background radiation is quantitatively explained in detail by the continuous cosmological formation of electrons (and attendant gravitons) from the aether. Part and parcel of an aether physical process that: ". . .converts free, nonelectric, nonelectromagnetic, nongravitic, 'latent thermal' or 'antigravitic' massfree energy into ORgone energy, or ambipolar electric radiation and, in the process, also converts other elements of the free nonelectric Aether into mass-energy (and thus monopolar electricity) and into gravitational energy." ❑❑❑

In Memoriam: Robert L. Forward

An old friend and professional colleague from the late 1960s onward, physicist and science fiction author Dr. Robert Lull Forward, passed away at age 70 in the early morning hours of September 21, 2002 in Seattle, Washington, following a several month battle with brain cancer.

I had spoken with Bob for the last time, by telephone, in late August 2002—an eerie and sad experience, since at that time he was in the process of passing faster than he had earlier anticipated. We knew this was the last conversation we would have. He was kind, upbeat, and articulate to the end, though his speech was labored. *Infinite Energy* had re-published a memorable article by him (see *IE* #9, "Mass Modification Experiment Definition Study"). Bob wrote his own obituary, which he submitted to the American Physical Society. It began: "The intelligent pattern of protoplasm that had been Robert L. Forward ceased coherent operation on September 21, 2002." So like him!

A summary of the rest of his APS obituary appeared on The Planetary Society's website (www.planetary.org):

"One of the world's leading experts in exotic physics and future space travel, Forward built and operated the first bar antenna for the detection of gravitational radiation (now in the Smithsonian), worked on the matter-antimatter propulsion system concept used in Star Trek, and promoted the concept of solar sailing. He authored 157 scientific papers and science texts on the possibilities of truly 'boldly going' where no humans have gone before. During a more than thirty-year tenure at Hughes Aircraft Company Corporate Research Laboratories in Malibu, California he created and designed spacecraft and propulsion systems that earned him numerous patents and ignited dreams of going to the stars. He also gained renown for melding his imagination to science for eleven 'hard' science fiction novels, the first of which, *Dragon's Egg*, was published in 1980.

"At the time of his passing, Forward was owner and chief scientist for Forward Unlimited, a consulting firm that specialized in exotic physics and advanced space propulsion, which he established in 1962; and chairman and chief scientist of its spin-off company, Tethers Unlimited, Inc., a partnership he formed in 1994 with Robert P. Hoyt, to develop highly-survivable space tethers and space tether systems.

"Forward is survived by his wife of 48 years, Martha Dodson Forward, and daughter Julie Forward Fuller, both of whom co-authored some of his novels; three other children—son Robert Forward of Chatsworth, California, and daughters Mary Lois Mattlin of Los Angeles, California, and Eve Forward-Rollins of Mill Creek, Washington; and seven grandchildren."

Downloads of many of Forward's papers can be obtained by visiting his website (www.ForwardUnlimited.com).

—Eugene Mallove

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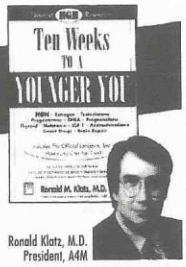

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The Top 30 Problems with the BIG BANG

Tom Van Flandern*

Abstract

Earlier, we presented a simple list of the top ten problems with the Big Bang.[1] Since that publication, we have had many requests for citations and additional details, which we provide here. We also respond to a few rebuttal arguments to the earlier list. Then we supplement the list based on the last four years of developments—with another twenty problems for the theory.

The Big Bang, much like the Santa Claus hypothesis, no longer makes testable predictions wherein proponents agree that a failure would falsify the hypothesis. Instead, the theory is continually amended to account for all new, unexpected discoveries. Indeed, many young scientists now think of this as a normal process in science! They forget, or were never taught, that a model has value only when it can predict new things that differentiate the model from chance and from other models before the new things are discovered. Explanations of new things are supposed to flow from the basic theory itself with, at most, an adjustable parameter or two, and not from add-on bits of new theory.

Perhaps never in the history of science has so much quality evidence accumulated against a model so widely accepted within a field. Even the most basic elements of the theory—the expansion of the universe and the fireball remnant radiation—remain interpretations with credible alternative explanations. One must wonder why, in this circumstance, four good alternative models are not even being comparatively discussed by most astronomers.

1. Static universe models fit observational data better than expanding universe models.

Static universe models match most observations with no adjustable parameters. The Big Bang can match each of the critical observations, but only with adjustable parameters, one of which (the cosmic deceleration parameter) requires mutually exclusive values to match different tests.[2,3] Without ad hoc theorizing, this point alone falsifies the Big Bang. Even if the discrepancy could be explained, Occam's razor favors the model with fewer adjustable parameters—the static universe model.

2. The microwave "background" makes more sense as the limiting temperature of space heated by starlight than as the remnant of a fireball.

The expression "the temperature of space" is the title of Chapter 13 of Sir Arthur Eddington's famous 1926 work.[4] Eddington calculated the minimum temperature any body in space would cool to, given that it is immersed in the radiation of distant starlight. With no adjustable parameters, he obtained 3°K (later refined to 2.8°K),[5] essentially the same as the observed, so-called "background," temperature. A similar calculation, although with less certain accuracy, applies to the limiting temperature of intergalactic space because of the radiation of galaxy light.[6] So the intergalactic matter is like a "fog," and would therefore provide a simpler explanation for the microwave radiation, including its blackbody-shaped spectrum.

Such a fog also explains the otherwise troublesome ratio of infrared to radio intensities of radio galaxies.[7] The amount of radiation emitted by distant galaxies falls with increasing wavelengths, as expected if the longer wavelengths are scattered by the intergalactic medium. For example, the brightness ratio of radio galaxies at infrared and radio wavelengths changes with distance in a way which implies absorption. Basically, this means that the longer wavelengths are more easily absorbed by material between the galaxies. But then the microwave radiation (between the two wavelengths) should be absorbed by that medium too, and has no chance to reach us from such great distances, or to remain perfectly uniform while doing so. It must instead result from the radiation of microwaves from the intergalactic medium. This argument alone implies that the microwaves could not be coming directly to us from a distance beyond all the galaxies, and therefore that the Big Bang theory cannot be correct.

None of the predictions of the background temperature based on the Big Bang were close enough to qualify as successes, the worst being Gamow's upward-revised estimate of 50°K made in 1961, just two years before the actual discovery. Clearly, without a realistic quantitative prediction, the Big Bang's hypothetical "fireball" becomes indistinguishable from the natural minimum temperature of all cold matter in space. But none of the predictions, which ranged between 5°K and 50°K, matched observations.[8] And the Big Bang offers no explanation for the kind of intensity variations with wavelength seen in radio galaxies.

3. Element abundance predictions using the Big Bang require too many adjustable parameters to make them work.

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The universal abundances of most elements were predicted correctly by Hoyle in the context of the original steady state cosmological model. This worked for all elements heavier than lithium. The Big Bang co-opted those results and concentrated on predicting the abundances of the light elements. Each such prediction requires at least one adjustable parameter unique to that element prediction. Often, it's a question of figuring out why the element was either created or destroyed or both to some degree following the Big Bang. When you take away these degrees of freedom, no genuine prediction remains. The best the Big Bang can claim is consistency with observations using the various ad hoc models to explain the data for each light element. Examples: References 9 and 10 for helium-3; Reference 11 for lithium-7; Reference 12 for deuterium; Reference 13 for beryllium; and References 14 and 15 for overviews. For a full discussion of an alternative origin of the light elements, see Hoyle *et al.*[16]

4. The universe has too much large scale structure (interspersed "walls" and voids) to form in a time as short as 10-20 billion years.

The average speed of galaxies through space is a well-measured quantity. At those speeds, galaxies would require roughly the age of the universe to assemble into the largest structures (superclusters and walls) we see in space,[17] and to clear all the voids between galaxy walls. But this assumes that the initial directions of motion are special, *e.g.*, directed away from the centers of voids. To get around this problem, one must propose that galaxy speeds were initially much higher and have slowed due to some sort of "viscosity" of space. To form these structures by building up the needed motions through gravitational acceleration alone would take in excess of 100 billion years.[18]

5. The average luminosity of quasars must decrease with time in just the right way so that their average apparent brightness is the same at all redshifts, which is exceedingly unlikely.

According to the Big Bang theory, a quasar at a redshift of 1 is roughly ten times as far away as one at a redshift of 0.1. (The redshift-distance relation is not quite linear, but this is a fair approximation.) If the two quasars were intrinsically similar, the high redshift one would be about 100 times fainter because of the inverse square law. But it is, on average, of comparable apparent brightness. This must be explained as quasars "evolving" their intrinsic properties so that they get smaller and fainter as the universe evolves. That way, the quasar at redshift 1 can be intrinsically 100 times brighter than the one at 0.1, explaining why they appear (on average) to be comparably bright. It isn't as if the Big Bang has a reason why quasars should evolve in just this magical way. But that is required to explain the observations using the Big Bang interpretation of the redshift of quasars as a measure of cosmological distance. See Van Flandern[19] and Arp.[20]

By contrast, the relation between apparent magnitude and distance for quasars is a simple, inverse-square law in alternative cosmologies. Arp[20] shows great quantities of evidence that large quasar redshifts are a combination of a cosmological factor and an intrinsic factor, with the latter dominant in most cases. Most large quasar redshifts (*e.g.*, $z > 1$) therefore have little correlation with distance. A grouping of eleven quasars close to NGC 1068, having nominal ejection patterns correlated with galaxy rotation, provides further strong evidence that quasar redshifts are intrinsic.[21]

6. The ages of globular clusters appear older than the universe.

Even though the data have been stretched in the direction toward resolving this since the "top ten" list first appeared, the error bars on the Hubble age of the universe (12±2 Gyr) still do not quite overlap the error bars on the oldest globular clusters (16±2 Gyr). Astronomers have studied this for the past decade, but resist the "observational error" explanation because that would almost certainly push the Hubble age older (as Sandage has been arguing for years), which creates several new problems for the Big Bang. In other words, the cure is worse than the illness for the theory. In fact, a new, relatively bias-free observational technique has gone the opposite way, lowering the Hubble age estimate to 10 Gyr, making the discrepancy worse again.[22,23]

7. The local streaming motions of galaxies are too high for a finite universe that is supposed to be everywhere uniform.

In the early 1990s, we learned that the average redshift for galaxies of a given brightness differs on opposite sides of the sky. The Big Bang interprets this as the existence of a puzzling group flow of galaxies relative to the microwave radiation on scales of at least 130 Mpc. Earlier, the existence of this flow led to the hypothesis of a "Great Attractor" pulling all these galaxies in its direction. But in newer studies, no backside infall was found on the other side of the hypothetical feature. Instead, there is streaming on both sides of us out to 60-70 Mpc in a consistent direction relative to the microwave "background." The only Big Bang alternative to the apparent result of large-scale streaming of galaxies is that the microwave radiation is in motion relative to us. Either way, this result is trouble for the Big Bang.[24-28]

8. Invisible dark matter of an unknown but non-baryonic nature must be the dominant ingredient of the entire universe.

The Big Bang requires sprinkling galaxies, clusters, superclusters, and the universe with ever-increasing amounts of this invisible, not-yet-detected "dark matter" to keep the theory viable. Overall, over 90% of the universe must be made of something we have never detected. By contrast, Milgrom's model (the alternative to "dark matter") provides a one-parameter explanation that works at all scales and requires no "dark matter" to exist at any scale. (I exclude the additional 50%-100% of invisible ordinary matter inferred to exist by, *e.g.*, MACHO studies.) Some physicists don't like modifying the law of gravity in this way, but a finite range for natural forces is a logical necessity (not just theory) spoken of since the seventeenth century.[29,30]

Milgrom's model requires nothing more than that. Milgrom's is an operational model rather than one based on fundamentals. But it is consistent with more complete models invoking a finite range for gravity. So Milgrom's model provides a basis to eliminate the need for "dark matter" in the universe at any scale. This represents one more Big Bang "fudge factor" no longer needed.

9. The most distant galaxies in the Hubble Deep Field show insufficient evidence of evolution, with some of them having higher redshifts ($z = 6$-7) than the highest-redshift quasars.

The Big Bang requires that stars, quasars, and galaxies in the early universe be "primitive," meaning mostly

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metal-free, because it requires many generations of supernovae to build up metal content in stars. But the latest evidence suggests lots of metal in the "earliest" quasars and galaxies.[31-33] Moreover, we now have evidence for numerous ordinary galaxies in what the Big Bang expected to be the "dark age" of evolution of the universe, when the light of the few primitive galaxies in existence would be blocked from view by hydrogen clouds.[34]

10. If the open universe we see today is extrapolated back near the beginning, the ratio of the actual density of matter in the universe to the critical density must differ from unity by just a part in 10.[59] Any larger deviation would result in a universe already collapsed on itself or already dissipated.

Inflation failed to achieve its goal when many observations went against it. To maintain consistency and salvage inflation, the Big Bang has now introduced two new adjustable parameters: 1) the cosmological constant, which has a major fine-tuning problem of its own because theory suggests it ought to be of order 10^{120}, and observations suggest a value less than 1; and 2) "quintessence" or "dark energy."[35,36] This latter theoretical substance solves the fine-tuning problem by introducing invisible, undetectable energy sprinkled at will as needed throughout the universe to keep consistency between theory and observations. It can therefore be accurately described as "the ultimate fudge factor."

Anyone doubting the Big Bang in its present form (which includes most astronomy-interested people outside the field of astronomy, according to one recent survey) would have good cause for that opinion and could easily defend such a position. This is a fundamentally different matter than proving the Big Bang did not happen, which would be proving a negative—something that is normally impossible (*e.g.*, we cannot prove that Santa Claus does not exist). The Big Bang, much like the Santa Claus hypothesis, no longer makes testable predictions wherein proponents agree that a failure would falsify the hypothesis. Instead, the theory is continually amended to account for all new, unexpected discoveries. Indeed, many young scientists now think of this as a normal process in science! They forget, or were never taught, that a model has value only when it can predict new things that differentiate the model from chance and from other models before the new things are discovered. Explanations of new things are supposed to flow from the basic theory itself with, at most, an adjustable parameter or two, and not from add-on bits of new theory.

Of course, the literature also contains the occasional review paper in support of the Big Bang.[37] But these generally don't count any of the prediction failures or surprises as theory failures as long as some ad hoc theory might explain them. And the "prediction successes" in almost every case do not distinguish the Big Bang from any of the four leading competitor models: Quasi-Steady-State,[16,38] Plasma Cosmology,[18] Meta Model,[3] and Variable-Mass Cosmology.[20]

For the most part, these four alternative cosmologies are ignored by astronomers. However, one website by Ned Wright does try to advance counter-arguments in defense of the Big Bang.[39] But his counter-arguments are mostly old objections long since defeated. For example:

(1) In "Eddington did not predict the CMB":

a. Wright argues that Eddington's argument for the "temperature of space" applies at most to our galaxy. But Eddington's reasoning applies also to the temperature of intergalactic space, for which a minimum is set by the radiation of galaxy and quasar light. The original calculations half a century ago showed this limit probably fell in the range 1-6°K.[6] And that was before quasars were discovered and before we knew the modern space density of galaxies.

b. Wright also argues that dust grains cannot be the source of the blackbody microwave radiation because there are not enough of them to be opaque, as needed to produce a blackbody spectrum. However, opaqueness is required only in a finite universe. An infinite universe can achieve thermodynamic equilibrium (the actual requirement for a blackbody spectrum) even if transparent out to very large distances because the thermal mixing can occur on a much smaller scale than quantum particles—*e.g.*, in the light-carrying medium itself.

c. Wright argues that dust grains do not radiate efficiently at millimeter wavelengths. However, efficient or not, if the equilibrium temperature they reach is 2.8°K, they must radiate away the energy they absorb from distant galaxy and quasar light at millimeter wavelengths. Temperature and wavelength are correlated for any bodies in thermal equilibrium.

(2) About Lerner's argument against the Big Bang:

a. Lerner calculated that the Big Bang universe has not had enough time to form superclusters. Wright calculates that all the voids could be vacated and superclusters formed in less than 11-14 billion years (barely). But that assumes that almost all matter has initial speeds headed directly out of voids and toward matter concentrations. Lerner, on the other hand, assumed that the speeds had to be built up by gravitational attraction, which takes many times longer. Lerner's point is more reasonable because doing it Wright's way requires fine-tuning of initial conditions.

b. Wright argues that "there is certainly lots of evidence for dark matter." The reality is that there is no credible observational detection of dark matter, so all the "evidence" is a matter of interpretation, depending on theoretical assumptions. For example, Milgrom's model explains all the same evidence without any need for dark matter.

(3) Regarding arguments against "tired light cosmology":

a. Wright argues: "There is no known interaction that can degrade a photon's energy without also changing its momentum, which leads to a blurring of distant objects which is not observed." While it is technically true that no such interaction has yet been discovered, reasonable non-Big-Bang cosmologies require the existence of entities many orders of magnitude smaller than photons. For example, the entity responsible for gravitational interactions has not yet been discovered. So the "fuzzy image" argument does not apply to realistic physical models in which all substance is infinitely divisible. By contrast, physical models lacking infinite divisibility have great difficulties explaining Zeno's paradoxes—especially the extended paradox for matter.[3]

b. Wright argues that the stretching of supernovae light curves is not predicted by "tired light." However, one cannot measure the stretching effect directly because the time under the light curve depends on the intrinsic brightness of the supernovae, which can vary considerably. So one must use

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indirect indicators, such as rise time only. And in that case, the data does not unambiguously favor either tired light or Big Bang models.

c. Wright argued that the tired light does not produce a blackbody spectrum. But this is untrue if the entities producing the energy loss are many orders of magnitude smaller and more numerous than quantum particles.

d. Wright argues that tired light models fail the Tolman surface brightness test. This ignores that realistic tired light models must lose energy in the transverse direction, not just the longitudinal one, because light is a transverse wave. When this effect is considered, the predicted loss of light intensity goes with $(1 + z)^{-2}$, which is in good agreement with most observations without any adjustable parameters.[2,40] The Big Bang, by contrast, predicts a $(1 + z)^{-4}$ dependence, and must therefore invoke special ad hoc evolution (different from that applicable to quasars) to close the gap between theory and observations.

By no means is this "top ten" list of Big Bang problems exhaustive—far from it. In fact, it is easy to argue that several of these additional twenty points should be among the "top ten":

❒ *"Pencil-beam surveys"* show large-scale structure out to distances of more than 1 Gpc in both of two opposite directions from us. This appears as a succession of wall-like galaxy features at fairly regular intervals, the first of which, at about 130 Mpc distance, is called "The Great Wall." To date, thirteen such evenly-spaced "walls" of galaxies have been found![41] The Big Bang theory requires fairly uniform mixing on scales of distance larger than about 20 Mpc, so there apparently is far more large-scale structure in the universe than the Big Bang can explain.

❒ Many particles are seen with energies over 60×10^{18} eV. But that is the *theoretical energy limit* for anything traveling more than 20-50 Mpc because of interaction with microwave background photons.[42] However, this objection assumes the microwave radiation is as the Big Bang expects, instead of a relatively sparse, local phenomenon.

❒ The Big Bang predicts that equal amounts of *matter and antimatter* were created in the initial explosion. Matter dominates the present universe apparently because of some form of asymmetry, such as CP violation asymmetry, that caused most anti-matter to annihilate with matter, but left much matter. Experiments are searching for evidence of this asymmetry, so far without success. Other galaxies can't be antimatter because that would create a matter-antimatter boundary with the intergalactic medium that would create gamma rays, which are not seen.[43,44]

❒ Even a small amount of diffuse neutral hydrogen would produce a smooth absorbing trough shortward of a QSO's Lyman-alpha emission line. This is called the *Gunn-Peterson effect,* and is rarely seen, implying that most hydrogen in the universe has been re-ionized. A hydrogen Gunn-Peterson trough is now predicted to be present at a redshift $z \approx 6.1$.[45] Observations of high-redshift quasars near $z = 6$ briefly appeared to confirm this prediction. However, a galaxy lensed by a foreground cluster has now been observed at $z = 6.56$, prior to the supposed re-ionization epoch and at a time when the Big Bang expects no galaxies to be visible yet. Moreover, if only a few galaxies had turned on by this early point, their emission would have been absorbed by the surrounding hydrogen gas, making these early galaxies invisible.[34] So the lensed galaxy observation falsifies this prediction and the theory it was based on. Another problem example: Quasar PG 0052+251 is at the core of a normal spiral galaxy. The host galaxy appears undisturbed by the quasar radiation, which, in the Big Bang, is supposed to be strong enough to ionize the intergalactic medium.[46]

❒ *An excess of QSOs* is observed around foreground clusters. Lensing amplification caused by foreground galaxies or clusters is too weak to explain this association between high-and low-redshift objects. This apparent contradiction has no solution under Big Bang premises that does not create some other problem. In particular, dark matter solutions would have to be centrally concentrated, contrary to observations that imply that dark matter increases away from galaxy centers. The high- and low-redshift objects are probably actually at comparable distances, as Arp has maintained for thirty years.[47]

❒ The Big Bang violates the *first law of thermodynamics*, that energy cannot be either created or destroyed, by requiring that new space filled with "zero-point energy" be continually created between the galaxies.[48]

❒ In the Las Campanas redshift survey, statistical differences from homogenous distribution were found out to a scale of at least 200 Mpc.[49] This is consistent with other galaxy catalog analyses that show no trends toward homogeneity even on scales up to 1,000 Mpc.[50] The Big Bang, of course, requires *large-scale homogeneity*. The Meta Model and other infinite-universe models expect fractal behavior at all scales. Observations remain in agreement with that.

❒ *Elliptical galaxies* supposedly bulge along the axis of the most recent galaxy merger. But the angular velocities of stars at different distances from the center are all different, making an elliptical shape formed in that way unstable. Such velocities would shear the elliptical shape until it was smoothed into a circular disk. Where are the galaxies in the process of being sheared?

❒ The polarization of radio emission rotates as it passes through magnetized extragalactic plasmas. Such *Faraday rotations in quasars* should increase (on average) with distance. If redshift indicates distance, then rotation and redshift should increase together. However, the mean Faraday rotation is less near $z = 2$ than near $z = 1$ (where quasars are apparently intrinsically brightest, according to Arp's model).[51]

❒ If the dark matter needed by the Big Bang exists, microwave radiation fluctuations should have *"acoustic peaks"* on angular scales of 1° and 0.3°, with the latter prominent compared with the former. By contrast, if Milgrom's alternative to dark matter (Modified Newtonian Dynamics) is correct, then the latter peak should be only about 20% of the former. Newly acquired data from the Boomerang balloon-borne instruments clearly favors the MOND interpretation over dark matter.[52]

❒ *Redshifts are quantized* for both galaxies[53,54] and quasars.[55] So are other properties of galaxies.[56] This should not happen under Big Bang premises.

❒ The *number density of optical quasars* peaks at $z = 2.5$-3, and declines toward both lower and higher redshifts. At $z = 5$, it has dropped by a factor of about 20. This cannot be explained by dust extinction or survey incompleteness. The Big Bang predicts that quasars, the seeds of all galaxies, were most numerous at earliest epochs.[57]

❒ The falloff of the power spectrum at

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small scales can be used to determine the *temperature of the intergalactic medium*. It is typically inferred to be 20,000°K, but there is no evidence of evolution with redshift. Yet in the Big Bang, that temperature ought to adiabatically decrease as space expands everywhere. This is another indicator that the universe is not really expanding.[58]

❒ Under Big Bang premises, the *fine structure constant must vary* with time.[59]

❒ Measurements of the *two-point correlation function* for optically selected galaxies follow an almost perfect power law over nearly three orders of magnitude in separation. However, this result disagrees with n-body simulations in all of the Big Bang's various modifications. A complex mixture of gravity, star formation, and dissipative hydrodynamics seems to be needed.[60]

❒ Emission lines for z > 4 quasars indicate higher-than-solar *quasar metallicities*.[61] The iron to magnesium ratio increases at higher redshifts (earlier Big Bang epochs).[62] These results imply substantial star formation at epochs preceding or concurrent with the QSO phenomenon, contrary to normal Big Bang scenarios.

❒ The absorption lines of *damped Lyman-alpha systems* are seen in quasars. However, the HST NICMOS spectrograph has searched to see these objects directly in the infrared, but failed for the most part to detect them.[63] Moreover, the relative abundances have surprising uniformity, unexplained in the Big Bang.[64] The simplest explanation is that the absorbers are in the quasar's own environment, not at their redshift distance as the Big Bang requires.

❒ The *luminosity evolution* of brightest cluster galaxies (BCGs) cannot be adequately explained by a single evolutionary model. For example, BCGs with low X-ray luminosity are consistent with no evolution, while those with high X-ray luminosity are brighter on average at high redshift.[65]

❒ The fundamental question of why it is that at early cosmological times, bound aggregates of order 100,000 stars (*globular clusters*) were able to form remains unsolved in the Big Bang. It is no mystery in infinite universe models.[66]

❒ *Blue galaxy counts* show an excess of faint blue galaxies by a factor of 10 at magnitude 28. This implies that the volume of space is larger than in the Big Bang, where it should get smaller as one looks back in time.[67]

Perhaps never in the history of science has so much quality evidence accumulated against a model so widely accepted within a field. Even the most basic elements of the theory—the expansion of the universe and the fireball remnant radiation—remain interpretations with credible alternative explanations. One must wonder why, in this circumstance, four good alternative models are not even being comparatively discussed by most astronomers.

Acknowledgments

Obviously, hundreds of professionals, both astronomers and scientists from other fields, have contributed to these findings, although few of them stand back and look at the bigger picture. It is hoped that many of them will add their comments and join as co-authors in an attempt to sway the upcoming generation of astronomers that the present cosmology is headed nowhere, and to join the search for better answers.

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About the Author

Dr. Van Flandern received his Ph.D. in astronomy from Yale University in 1969. He spent twenty years at the U.S. Naval Observatory, where he became the Chief of the Celestial Mechanics Branch. Dr. Van Flandern has since formed a Washington, D.C.-based organization, Meta Research, to foster research into ideas not otherwise supported, solely because they conflict with mainstream theories in astronomy. He is a research associate at the University of Maryland Physics Department, where he does research on the accuracy of the Global Positioning System. Dr. Van Flandern has published *Dark Matter, Missing Planets, and New Comets* (North Atlantic Books). He was the recipient of a prize from the Gravity Research Foundation; served on the Council of American Astronomical Society's Division on Dynamical Astronomy; taught astronomy at the University of South Florida and to Navy Department employees; and appeared on the "Project Universe" series that airs occasionally on public television.

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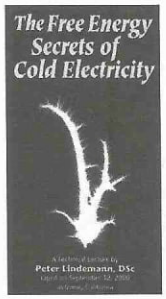

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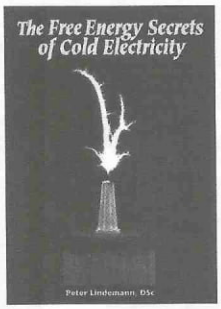

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The BIG BANG Theory: A Retrospective

Arnold G. Gulko*

For the past seventy years the Big Bang theory has dominated modern cosmology. This theory was initially based on observations made in the 1920s by Edwin Hubble, who found that light from distant galaxies was shifted toward the red, this redshift being roughly proportional to the distance of the galaxy from us measured by its bolometric magnitude.

Galaxies have different intrinsic luminosities, although one can rely on average luminosity, which ignores the variation. Also, as in the galaxies close to us, any individual galaxy can move in any direction, but one can also ignore this motion because the motion of an individual galaxy is relatively slow. So while the data is scattered, there is a generally straight line relationship between distance and redshift when the data is appropriately graphed. It follows that one can judge the distance of a remote galaxy from us by the extent to which its light is shifted toward the red.

A shift toward the red can identify recessional motion, the analogy to the Doppler effect with sound being relied upon to support this conclusion. On this basis many have concluded that stellar redshift identifies recessional motion. But if everything were moving away, with the more distant the object the more rapid its recessional motion, then what we see might be the product of some initial primordial explosion which hurled everything outwardly. This reasoning brought the Big Bang theory into existence.

Hubble considered this theory in his 1939 text[1]—and he rejected it. The thought that everything had its inception in a single explosive release of energy troubled him; perhaps he could also see the scarcity of other corroboration. On the other hand, he could not dismiss the possibility that photons of light might lose a tiny bit of energy as they traversed the immense distances they travel through space. Those favoring the Big Bang theory sneered at Hubble's alternative explanation of the stellar redshift, terming it the "tired light" theory.

So the birth of the Big Bang theory was accompanied by an initial dispute which has never been entirely resolved. This writer makes three points.

First, the puzzle is normally presented as a choice of one view or the other. It is possible for the stellar redshift to have a mixed origin—a portion thereof being due to a loss of energy as light traverses space and a portion being due to recessional motion.

Second, physicists have never liked the concept of perpetual motion, because every known action involves at least a slight loss, albeit a loss that might be so minuscule as to escape measurement here at Earth. In the Big Bang theory, light must traverse space for a distance of millions or billions of light-years without even a small energy loss! When one compares the astrophysicists' "sneer" with common experience, one sees how little support it really has.

Third, light is very unlike a projectile phenomenon. When energy is released that initiates a photon, it instantly moves away at light speed, its velocity being independent of its energy content. It seems clear that a photon is a concentration of energy which is carried through space by a wave generated by contact between that photon and some residual energy filling space, which functions to

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When we look for predictions of the Big Bang theory which have been correct, or observations which have been logically explained, it is hard to find them. All we find is a compilation of wild and unsupported possibilities.

propagate the wave at a natural velocity (light speed). If that be so, then it makes sense for the photon to lose a tiny amount of energy to sustain the wave that carries it.

Hubble's reluctance to accept recessional motion as the explanation for cosmic redshift made little impact in the early years of the Big Bang theory. He was brushed aside, along with his conclusions, based on observations seeming to indicate that the larger elliptical galaxies contracted as they spun, becoming progressively smaller as they became progressively flatter. Those observations suggested a logical process of galactic evolution, but that evolution was rejected by the Big Bang theorists.

Two concepts provoked by our experience with ordinary explosions dominated early Big Bang thinking.

First, to provide some basis for recessional velocity to become greater with increasing distance, an expanding balloon metaphor for space (actually, "space-time") was employed. An explosion normally produces an expanding sphere in which its debris is concentrated at the surface of the sphere. If one places dots on the surface of a balloon and blows up that balloon, the dots move away from one another, with the farther dots (from a reference dot) moving away more rapidly. This is exactly what was suggested by the redshift evidence, combined with the concept that the recessional motion resulted from a primordial explosion that formed all we now see. However, back in the 1920s and 1930s our telescopes could see only the closer objects and we had little knowledge of the shape of the visible universe or the distribution of objects therein.

The second concept arising from our experience with explosions is uniformity of distribution. This manifested itself as the "cosmological principle," in which the material ejected by the primordial explosion had to be uniformly distributed even though it might be largely confined to a "spherical surface," per the expanding balloon metaphor. Accordingly, the Big Bang theory spawned the assumption that the objects we see in space were uniformly distributed. One glance at the night sky reveals that the closer celestial objects are not uniformly distributed, so the assumed uniformity was supposedly present on the larger scale of galaxy distribution. The evident lack of a uniform mass distribution within the visible universe will be discussed later.

The main purpose of any cosmological theory is to understand our own origin. We live on a planet which circles a star, and that star is one of billions that orbit the center of our Milky Way galaxy. Individual stars are clearly formed by the gravitational ingathering of particles. The Big Bang theory concluded that galaxies were formed in the same way. More particularly, the primordial explosion supposedly released energy which formed particles that eventually were gravitationally concentrated into clouds, within which large number of stars ultimately formed to provide the bright galaxies we see.

But these clouds, like the clouds in the sky, would have all sorts of shapes, so they could not have formed the large elliptical galaxies, which are remarkably regular in shape. One problem with Hubble's galactic evolution was the lack of any source of the large elliptical galaxies he had observed. The Big Bang theory instead assumed that the early galaxies were small and somewhat flat and tended to spiral, the larger elliptical galaxies being formed by the merger of the smaller spirals. One can now see that Hubble's concept of galaxy evolution was disregarded along with his "tired light" idea, even though Hubble had observational support and the Big Bang alternative was mostly based on conjecture.

So everything seemed to be simple and logical in the early Big Bang theory, and this led to its general acceptance. It gave us a uniform distribution of objects concentrated on a "spherical shell," it explained a redshift which became progressively greater with distance, and it gave us a plausible scenario for the formation and evolution of the galaxies, one of which we call our home.

The merit of any theory is measured primarily by its capacity to make correct predictions. A second factor to be considered is its capacity to make sense out of observations. The Big Bang theory had a reasonably good start, as set forth above, but could it stand the test of subsequent observations?

Astronomers continued to examine the sky with ever-improving equipment, and they kept finding things which bothered those with open minds.

The astronomers mapped the galaxies and found that they were not uniformly distributed. The galaxies were instead clustered together in groups; and some of these groups were very large, containing more than a thousand galaxies. These very large clusters were called "superclusters," which were separated by regions of space containing few galaxies,

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these being called "voids." The voids were just as large as the superclusters. So, at least for the galaxies which our telescopes could see, the assumed uniformity was not present.

In the Big Bang theory, the universe was estimated to have an age of not more than about 20 billion years, so it is not very old and gravity is a very weak force. Indeed, gravity was far too weak and the available time was far too short to form the superclusters or to remove the galaxies from the voids. So the basic concept of an initial uniformity followed by gravitational ingathering did not withstand examination. Those favoring the Big Bang theory doubted the evidence of non-uniformity until it was overwhelmingly established.

A remarkably uniform microwave background radiation corresponding to a very low temperature of about 3° Kelvin was also found; it was assumed to be a remnant of the Big Bang's primordial explosion in a rapidly expanding universe. This finding forced astrophysics to try to reconcile an explosion forming a uniform background remnant with the production of a remarkably non-uniform distribution of galaxies. In response to this problem, astrophysics assumed that when the microwave background had been carefully examined it would be found to contain initial non-uniformities (anisotropies), which matured into the non-uniform distribution of galaxies then being documented.

By 1970, Peebles and Silk had calculated that the anisotropy of the microwave background should amount to five or six parts per thousand. By 1979, it was clear there was no anisotropy at even one part in ten thousand—and every theory required at least a few times that amount. Nonetheless, we now know that the anisotropies are far smaller than even that!

As time passed it became clear that the universe did not resemble a "spherical shell," for there were about the same number of objects in every direction while a shell should contain few galaxies outside the domain of the shell. This uniformity of distribution with direction extended even to very remote objects, such as quasars. The redshift had to be explained without reference to the expanding balloon metaphor, and astrophysics responded with the concept of the expansion of space.

The concept of expanding space (actually, "space-time") is weird on its face, for space was suggested to be empty and it is hard to comprehend how it might expand and how such expansion might influence massive objects, like galaxies. But it is this expansion which allowed the formation of hydrogen to be relied upon as the source of the microwave background, even though the energy released by hydrogen formation was at a much higher temperature. Most of the photons released when hydrogen forms correspond to a temperature of about 140,000° Kelvin, while the background radiation has a remarkably uniform temperature of about 2.7° Kelvin. How could expansion force such an immense change, and where was the evidence of hydrogen's spectrum? However, alternative explanations were even less persuasive.

Another problem with the microwave background radiation is the absence of a strong gamma-ray background. A primordial explosion would have released energy which converted to particles, and many of these would have been antiparticles. These antiparticles have an opposite electrical charge and they should have annihilated particles at the same time and in the same place as is suggested for the formation of hydrogen. When we impose well-known physics upon the concept of a primordial explosion producing all we see, it becomes evident there must be a powerful gamma-ray background, but this is not present.

As the evidence came in it became clear that the radius of the visible universe was very large, at least 14 billion light-years, so what we see extends for a total distance of 28 billion light-years. The best estimate of the age of the Big Bang universe is about 15 billion years, so the various portions of the visible universe are clearly unable to communicate with one another, even at light speed. To accommodate this and related problems the Big Bang theory was modified to suggest an initial "inflationary" period at a velocity enormously faster than light speed. This inflationary theory demanded a mass-density exactly equal to that needed to stop the expansion, but not large enough to reverse it.

In initial thinking, the primordial explosion which produced an expanding universe would eventually be reversed in a "Big Crunch," which could reproduce the mass concentration that exploded to form our universe and thus lead to the formation of another universe. But with the mass density demanded by inflationary theory this was impossible, so the Big Bang theory now contains no basis for the formation of a universe to replace this one when it has consumed its nuclear fuel and is "dead."

Worse, detectable matter was found to constitute only about 4% of the mass needed to stop the expansion, so there is no basis in Big Bang thinking for the regeneration of our universe. Even with the aid of never-detected "dark matter," there is not a sufficient mass density to stop the expansion. Accordingly, inflationary theory is rebutted and in our quest for the capacity to understand the origin of our universe, the Big Bang theory has failed, unless one concludes (as some now do) that the Big Bang formed everything from nothing—which is evident nonsense.

The concept of an expanding universe intrinsically demands that the outer regions of the expanded space be enormously stretched and contain few particles per volume of space. In turn, this demands that the most remote space we see should contain few galaxies. But the Hubble Space Telescope made a mosaic of extremely remote space and found that it contained an object density about 90 times greater than our region of space! The expanding universe of the Big Bang theory does not match the observations.

The cosmological principle insisted that if the scale of observation was large enough, the mass distribution within the visible universe should be uniform; so astronomers mapped the galaxies on an ever-larger scale. Rather than find greater uniformity with increasing size, they found larger galaxy clusters and even structures such as "walls" of enormous size, which logically cannot be formed by a process of gravitational ingathering. This is because such a process cannot produce objects which are flat, and walls are generally flat in shape, being far longer than they are wide and also relatively thin. As the mapping continued, the subject observations became quite convincing, and the cosmological principle is now being abandoned with respect to the visible universe.

While the galaxies close to us move in every direction, the overall motion in the Big Bang theory had to be outward (away from the site of the explosion). However, astronomers also found coordinated motions of enormous size in other directions, and these also could not have been established by gravity within the time of our universe's Big Bang existence.

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The essence of Big Bang thinking was a primordial explosion which formed particles having an overall outward motion, these particles now having been gathered together by gravity to form what we see. We have never understood this primordial explosion, so the puzzling mass distribution which it led to might simply be some unknown attribute of an event beyond our knowledge. Nonetheless, the essence of the thinking was that objects were formed in space by a process of growth resulting from the action of gravity over time. This growth concept, unlike the cosmological principle, is still maintained.

But the evidence did not support the growth concept, as simple and fundamental as that concept is. The evidence instead showed that the larger clusters of galaxies were far away. Indeed, the largest cluster containing the most galaxies was recently found more than six billion light-years away! Objects at that distance must be six billion years younger than we are (in Big Bang thinking), so the clusters near us had six billion more years in which to grow. The remote clusters should thus be smaller, not larger, as is now seen to be the case.

The concept of clouds of particles coming together to form the galaxies we see encountered other problems. Large particulate clouds were found which showed no tendency to form a galaxy. How could many particulate clouds form galaxies while some did not? Indeed, when we considered how weak gravity is and with only about 15 billion years in which to act, it was clear that a large particulate cloud should not form a dense and bright galaxy of the type we see. Something was needed to solve this problem.

Astronomy came up with other related surprises. Astrophysics thinks it can calculate the actions of gravity even though we do not understand how it works. Within our own solar system, the farther a planet is from the Sun, the slower its orbital motion. Kepler presented this finding, now known as Kepler's law, and Newton later explained it by demonstrating that gravity follows an inverse square law, so as to diminish in strength rapidly with distance. On this basis a planet close to the Sun must move very rapidly to prevent it from falling into the Sun. Correspondingly, a planet far from the Sun must move slowly or it would be flung out into interstellar space.

However, the stars in our own and other nearby galaxies do not follow Kepler's law, the outermost stars moving at least as fast as those far closer to the galactic center. Moreover, the galaxies orbiting clusters of galaxies move more rapidly than makes sense in the light of the mass of the clustered galaxies. What might cause these weird actions?

Astrophysics came up with "dark matter." This matter supposedly possesses a gravitational action, but avoids all other responses, such as the interaction with light possessed by all the matter we know. If this dark matter provided four to five times more mass than we can see, then that additional mass might provide enough gravity to prevent the outermost stars from escaping the galaxy (and they show no tendency to leave it). However, this additional gravity should cause the inner stars to fall rapidly into the large black holes present at the centers of galaxies, and they show no tendency to do this. The result is an observational mess ("gravitational lensing" does not corroborate a halo of dark matter) and a theoretical quandary (no known particle is available to constitute dark matter).

It was previously noted that the initially-formed galaxies in the Big Bang theory were spiral galaxies, which supposedly merged with one another to form the larger elliptical galaxies. So the proportion of spiral galaxies should increase with increasing distance where we see objects which are younger than those near us.

The Hubble Space Telescope pictured remote space and made several significant findings. First, intermediate space should have shown evidence of galactic mergers, and it did not. Second, the remote galaxies should have included a large proportion of spiral galaxies and very few were present. Third, the most remote objects should have been the primordial galaxies, and the Big Bang theory had predicted these should be large, of irregular shape, and emit dim light mostly in the infra-red, as the light from a few stars was absorbed and re-emitted by the surrounding particles. The COBE spacecraft searched for these primordial galaxies in the infrared and could not find them. The Hubble Space Telescope instead found that a large number of objects in extremely remote space were small, round, bright, and the light they emitted was mostly in the ultraviolet. So the young universe seen in remote space does not resemble that predicted by Big Bang thinking and the Big Bang concepts for the evolution of galaxies are rebutted by the evidence.

The Big Bang concept of spiral galaxies being more prevalent in the early universe and the companion concept that the more remote objects must be younger came into focus several years ago when a dense cluster of galaxies (Abell 851) about four billion light-years away was carefully examined. It was found that the proportion of spiral galaxies was significantly greater in this remote cluster of galaxies. Since the cluster was four billion light-years away, the Big Bang theory demanded that it be much younger than the galaxies near us. Astrophysics exulted because its prediction that younger galaxies would include a larger proportion of spiral galaxies had been corroborated. The exultation was short-lived, however; it was squelched by later observations, including the previously noted findings of the Hubble Space Telescope.

Gravity acting over time should bring the galaxies closer together, so based on its density the Abell 851 cluster of galaxies should be billions of years older than those near us. Of course, this is nonsense in the Big Bang theory for galaxies which are billions of light-years away. As previously noted, it was later established that remote space contains few spiral galaxies and the proportion of spiral galaxies generally increases as we come closer to Earth. So the large proportion of spiral galaxies in the remote cluster actually confirms the suggestion that greater density indicates this particular remote cluster is older than we are.

The age problem is illustrated when we consider this ancient cluster of galaxies. The oldest objects in our galaxy are about 15 billion years of age, and this matches the best Big Bang estimate for the age of our visible universe. But the noted evidence suggests that this dense cluster of galaxies is probably four billion years older than our galaxy, so it should include objects which are 19 billion years of age. But what we see in light arriving from a distance of four billion light-years is four billion years old, so some objects in this remote cluster are now about 23 billion years old. The age of the universe suggested by the Big Bang theory does not match the evidence.

There are other observations which throw the age of the universe into doubt. Thus, the most remote particulate clouds should be almost entirely constituted by hydrogen and helium. The heavier elements would only be scattered into space as massive stars exploded in supernova events, so the proportion of these heavier elements in a particulate

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cloud would slowly increase with time. This means that very remote particulate clouds should contain very little of the heavier elements, like silicon or iron. Instead, very remote particulate clouds have been found which contain large proportions of these heavy elements.

It is not at all unusual for objects in the cosmos to be out of place from the standpoint of their age. Several illustrations of very old objects being found in remote locations where they should not exist in a Big Bang universe have previously been noted, but the reverse is also true. Thus, quasars are young objects and most of those which are strong gamma-ray emitters are at least about six billion light-years away. Nonetheless, quasar 3C 273 is a strong gamma-ray emitting quasar, and it is only about two billion light-years away. So this mixed up visible universe also contains very young objects which are relatively close to us.

The universe is confused in many ways in Big Bang thinking. On the one hand, inflationary theory demands a universe containing just enough mass to stop the expansion, but matter of the type we see on Earth constitutes at most only about 4% of this amount. Even including dark matter, we only have about 30% of this amount. Nonetheless, the microwave background is now being construed to suggest that the mass content is 100% of the theoretically necessary amount. So even the amount of mass is a chaotic factor in Big Bang theorizing.

Let us switch from the amount of mass to its motion. The Big Bang theory has always assumed that the mass we see in the visible universe is all that exists, so the gravity produced by that mass should slow the outward expansion of what we see. But observation of remote supernovae is now said to establish that the outward expansion is accelerating rather than slowing. This is attributed to "dark energy" pushing the galaxies apart, this repellent dark energy constituting the missing 70% of the universe. But this dark energy has no basis in existing physics and was a considerable surprise. The Big Bang theory had to come up with something to accommodate the observations!

Assuming that the remote galaxies are accelerating away from us, as is now concluded, then dark energy does not act close to us and only becomes effectively repellent with increasing distance. However, at even greater distances, such as 10 billion light-years, it has been found that the galaxies are slowing! So this repellent action, which supposedly increases with distance, does not continue to do so as the distance continues to increase!

Accordingly, the motion of the mass we can see is also chaotic, but let us try to understand. The rate of expansion of the Big Bang universe was underestimated, and this is attributed to dark energy constituting two-thirds of the total energy content of the universe. But the mass density had been determined to be enormously too small to reverse the supposed expansion and thus provide a basis for another Big Bang universe. If the expansion is faster than was thought, and if most of the energy has a repellent action, these facts worsen the problem, because the mass density was far too small to stop the previously assumed slower expansion! The chance of having the existing universe lead to another thus becomes even slimmer than it was before.

So when we look for predictions of the Big Bang theory which have been correct, or observations which have been logically explained, it is hard to find them. All we find is a compilation of wild and unsupported possibilities.

The single supposed quantitative success of the Big Bang theory is the prediction of the abundances of the lightest elements. As stated by Eric J. Lerner in his book *The Big Bang Never Happened*,[2] the Big Bang theory predicts the abundances of helium, lithium, and deuterium as a function of the density of matter in the universe. Lerner then notes that beginning in April 1991 a growing number of observations showed that these predictions were wrong. There is less helium than the theory predicts, and far less deuterium and lithium. No single amount of matter comes out right for all three elements at any initial cosmic density.

There are all sorts of additional problems, but the foregoing should be adequate to establish that the Big Bang theory has been a total failure in every direction. It has failed to make correct predictions, and even its simplest and most fundamental precepts have been shown to be wrong. When we look at the observations we find one confusion after another. From the basic standpoint of trying to understand the existence of our universe or the formation and evolution of the galaxies, the result is unsatisfactory. How can scientists maintain such a ludicrous theory? How can they ignore logical alternatives, such as that presented by this writer since 1980 in his texts and papers [such as "The Universe Cycle and the Observations," unpublished but referenced in Eugene Mallove's editorial in this issue, p. 7]? That alternative explains the various observations discussed above—and much more—and it has predicted many of the facts which astrophysics now largely ignores. The same can not be said for other theories that reject the Big Bang. ❑❑❑

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About the Author

After serving in the Army Air Corp in World War II, Mr. Gulko obtained a degree in chemical engineering and then spent four years as an Examiner in the United States Patent Office. Upon obtaining a degree in law, he passed the Virginia Bar and entered the private practice of patent law, representing diverse clients from 1952 to 1988. Mr. Gulko then retired to devote his time to fundamental studies in physics and astrophysics. Starting in 1980 he published thirteen texts, three of which are devoted to fundamental physics, the remainder being directed to the astrophysics generated by the physics. He is presently working on the use of nuclear forces in the formation of fractional hydrogen using electron beam technology.

*1835 Arcola Avenue, Silver Spring, MD 20902
E-mail: Aggulko@aol.com
Website: http://members.aol.com/Aggulko

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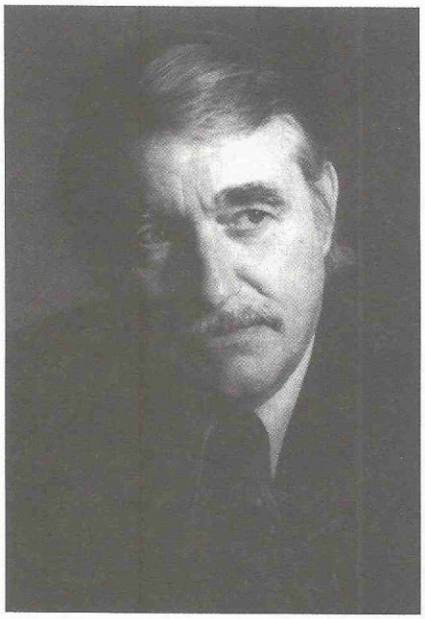

Halton Arp

An Appreciation of HALTON C. ARP

Robert A. Harman*

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If I were asked to name Lord Roberts's highest intellectual quality I should say unhesitatingly that it was his instinct. And if I were asked to name his highest moral quality I should say, also unhesitatingly, that it was the unshakeable confidence with which he trusted his instinct. But the firmness of his trust was not due in the least to self-conceit, or arrogance, or obstinacy. He obeyed his instinct as he obeyed his conscience. . .The dictates of both proceeded from the same source. It was not his own cleverness which led him to his conclusions, but the hand of Providence which drew aside a veil, and enabled him to see the truth. . .He had the gift of stating his conclusion with admirable lucidity; and if he thought it desirable, he gave the reasons for his view of the matter with an equal clearness. But his reasons, like his conclusion, were in the nature of statements; they were not stages in an argument. There are as many unanswerable reasons to be given for as against most human decisions. Ingenuity and eloquence are a curse at councils of war, and state, and business. Indeed, wherever action of any kind has to be determined upon they are a curse. It was Lord Roberts's special gift that, out of the medley of unanswerable reasons, he had an instinct for selecting those which really mattered, and keeping his mind close shut against the rest.[1]

—Frederick Scott Oliver's description (1915)
of his colleague Lord Roberts

Introduction

It is the way of great souls to give their discoveries freely to the world. And it is the way of the Little Man to ignore or denigrate what is freely given, simply because he cannot understand the act of giving and because he cannot allow himself to love that which is alive, mobile, and full of infinite possibility of development. Thus, the giver is praised only when he is safely in his grave and his discoveries can also be buried in the dusty corners of libraries or museums, where they can no longer threaten settled ways of living and thinking.

This article is an effort to appreciate, while he is still with us, one of our greatest living scientists, the astronomer Halton C. Arp. It is an attempt to tell the story, and paint a portrait, of a scientific pioneer, in the context of his times. Nothing could be more rewarding than to understand the workings of a great scientific mind reaching out to the unexplored realms of the universe. Without some comprehension of the functioning of the scientific pioneer, our knowledge of the full depth of human experience is incomplete. Furthermore, until we understand the obstacles that certain elements of society place in the path of the pioneer, and how he overcomes them, we are in no position to find workable solutions for the problems that beset our world today.

The Work of Halton Arp

Halton Arp was born in 1927, around the time that Edwin Hubble made two of astronomy's most pivotal discoveries:

1. The so-called "white nebulae" are not "clouds" inside the Milky Way, but are other galaxies, each containing hundreds of billions of stars, each located millions of light-years away. Prior to this it had been believed that the Milky Way, our galaxy, was the entire observable universe.

2. The "redshift" of galaxies is numerically related to their apparent brightness. "Redshift" is a shifting of the patterns (spectral lines) of light toward the red end of the

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spectrum. Hubble discovered that the smaller and fainter the galaxy appears, the greater is its redshift.

We *now* know, thanks to Arp's research, that Hubble's discoveries opened the door to the comprehension of both the infinite vastness of the universe and the infinite variability of natural functioning shown in the creation of matter and in the birth of new galaxies. However, by the early 1950s, when Hubble, at the end of his career, gave the young Arp his first job, the astronomical community had frozen itself into a set of mechanical assumptions and abstract equations that closed and locked the door that Hubble had opened.

In order to better appreciate the difficulties that Arp had to overcome, it is necessary to give an overview of how this unfortunate situation came about: To describe the cosmos astronomers need to know how far away are the objects that they observe. For example, our view of the universe changed dramatically when Hubble showed that the "bright nebulae" were not thousands but millions of light-years away. In order to make sense of the newly discovered vastness of the cosmos, astronomers then searched for a way to measure the tremendous distances involved. Unfortunately, the mechanistic impulse to have "an answer" prevailed by accepting and promoting the view that the redshift was a "cosmic yardstick" that could be used mechanically to measure cosmic distances. This was based on the belief that an "expanding universe" resulted in a rigid "redshift-distance relationship."

The belief that the universe is filled with cosmic yardsticks is, in fact, an illusion since "measuring rods" of all types are human inventions, not fundamental manifestations of nature.

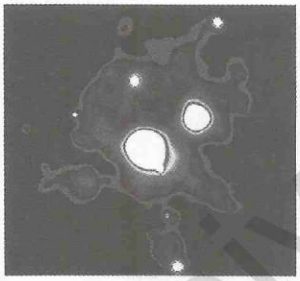
> The quantities in nature, as for instance the length of a line or the rate of speed of a motion, are artificial interferences of the human intellect with natural functioning. Nature functions, man measures its functions. (Reference 2, p. 180)

It was wishful thinking, on the part of those scientists who lacked the full capacity for sound scientific judgment, to assume that nature would provide them with a measuring rod that would make judgment unnecessary in the determination of distances. This attitude is an artifact of the mechanized civilization of the twentieth century.

This, then, was the scientific atmosphere in which Arp began his career. He had no choice but to work in a social system (academic science) that held, as its ideal, an intricate intellectual belief system that offered the redshift-distance relationship as a path of least resistance, enabling any young astronomer to mechanically produce "results" that fit smoothly into a self-reinforcing worldview. The same prevailing beliefs created serious and complicated obstacles for anyone who attempted to follow the more demanding path of observing nature as it exists.

Arp, however, was not sidetracked by the temptations of quick "answers" or the distractions of elaborate dogma. He somehow managed to acquire status in the scientific community while retaining the ability to simply observe the cosmos. [Such status is especially necessary for an astronomer who needs access to giant telescopes whose cost is beyond the reach of an individual. It is, rightfully, earned by demonstrating the capacity for productive research as well as by years of service to universities and scientific organizations.] This must have required remarkable personal qualities on Arp's part. He also had help from the healthier tendencies in academic tradition, which were stronger at that time than they are now, such as fair play for members of the academic community and continued recognition of a scientist's rightfully earned standing.

SEEING RED



Redshifts, Cosmology and Academic Science

by Halton Arp

QUASARS, REDSHIFTS AND CONTROVERSIES

by Halton Arp

By the 1960s Arp was observing so-called "peculiar galaxies." At that time, "normal" galaxies were perceived as "vast, placid aggregates of majestically orbiting stars." (Reference 3, p. 4) This perception, erroneous as it turned out, was, unlike the "redshift-yardstick," not intellectual or mechanistic, but the opposite—a mystical view akin to the old idea of the "*music* of the spheres," the "*harmony* of the universe." (Although, if we apply the musical metaphor accurately, the mystical perception in its most extreme form is one of *unison* rather than harmony. [Along this line, Arp points out (Reference 4, p. 170) that reactionary elements in the papacy tried to hold back the development of polyphonic music.] Looking at photographs of typical spiral galaxies, it is easy to see how this misperception seemed credible. These galaxies actually are, as one can sense from the photographs, spinning majestically. However, such pictures show each galaxy as a whole, not in its infinite detail. Also, they show only a "snapshot" of the galaxy at an instant in time, but the "life" of a galaxy spans billions of years.

Arp dealt with this limitation by studying galaxies that were not so placid. These were the galaxies whose whole structure was "disturbed" or "peculiar." In most cases, they were later shown by Arp to be galaxies whose "centers were the sites of enormous, variable outpourings of energy." (Reference 3, p. 4) To this day, however, many such "peculiar" galaxies are still regarded by academic astronomy as mere curiosities, galaxies mechanically disrupted by random, meaningless events such as an accidental "collision with another galaxy." How did Arp *know* that these objects were not mere curiosities, but worthy of years of his observational efforts? One can only attribute it to a rare, instinctive quality of "good judgment" on Arp's part. In this case, we can guess that his "judgment" must have been rooted in a desire to visualize the universe *in motion* and that this desire must have come from his gut feeling for the *spontaneous mobility* of all fundamental natural phenomena.

Arp published his first "Atlas of Peculiar Galaxies" in 1966. As a result hundreds of the most important (important from

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the standpoint of astrophysical research) galaxies are named after him. In the same year he first noticed that some quasars appeared close to and aligned across some of the particularly disturbed galaxies. [Quasars, discovered in 1963, are highly energetic objects. When their redshifts were measured they were found to be larger than the redshifts of any objects previously observed.] This was astonishing because, according to the redshift-yardstick, the quasars were *billions* of light-years away but the peculiar galaxies were much, much closer. Were the quasars indeed in the neighborhoods of the nearby peculiar galaxies or were they off at the edge of the universe? Arp had to "choose" between what he saw with his own eyes and the beliefs [the "redshift-distance relationship," the "expanding universe," the "Big Bang," and so forth] that were considered the indispensable foundation of modern astrophysics. He put his faith where it belonged, in his own ability to look at a simple photograph and see what was there.

> What Pericles said about the Little Man more than 2,300 years ago is as true today as it was then, just as true of the highly educated professor of astrophysics as it was of the Athenian mob:
>
> Praises spoken of others are only endured so far as each one thinks that he is himself also capable of doing any of the things he hears; but that which exceeds their own capacity men at once envy and disbelieve.

He presented his findings to a colloquium at Caltech in March 1966 and met with the ugly contempt that was to plague him for the rest of his career. One colleague sarcastically announced, "Well, this will be the shot heard around the room!" [A clever twist on the famous poem that describes the first battle of the American Revolution as "the shot heard 'round the world." The cleverness and contempt were misplaced: Arp's discovery *truly* was revolutionary.] Only a small number of astronomers were willing to follow, at least part of the way, on the path that Arp had discovered. These included some well-known scientists such as Fred Hoyle, E. Margaret Burbidge, Geoffrey Burbidge, Jayant Narlikar, and William Tifft. Arp recalls the scorn that they received:

> Tifft had impeccable credentials and a record of serious, careful research. Nevertheless I was treated to some lunchtime conversation at Caltech in which an influential astronomer joked (well, everyone laughed) about retroactively canceling his degree. (Reference 4, p. 112)

Younger colleagues fared worse: One talented researcher, K.G. Karlsson [Karlsson discovered the crucial "Karlsson formula" for the quantization of redshifts] found himself "unemployable" as an astronomer and became a physician. Another, Hans-Dieter Radecke, literally wound up on unemployment and had to change to a career in technical science writing. [Radecke discovered extended gamma ray emissions in the Virgo supercluster, including one connecting the quasars 3C273 and 3C279. This implies that high-energy photons are originating from an enormous area in space that contains very little matter, a finding that completely overturns mechanistic ideas of the relationship between matter and electromagnetic energy.]

In 1968 Arp followed an intuitively brilliant inspiration and reversed his usual procedure. Instead of starting with a galaxy and looking for nearby quasars, he started with highly energetic radio sources, which were known to occur in pairs, and looked to see whether there was a galaxy between each pair. Arp was intuitively thinking in two directions:

1. The first direction was in his original procedure of starting with an important expression of natural functioning (a peculiar galaxy) and finding what develops from it (the associated quasars).

2. The second direction was in his 1968 procedure of starting with paired developments (the radio sources) and finding their origin (the galaxy).

The first type of thinking enables us to discover how known functions develop. The second type leads into deeper realms of nature.

The second way of thinking makes it possible to find associations between galaxies and several different kinds of highly energetic objects, even when these objects are no longer in the immediate neighborhood of the galaxies. [Such as the pair of radio sources 3C274 (the jet galaxy M87=VirgoA=Arp152) and 3C273 (the brightest known quasar), which are aligned across the extremely bright galaxy M49 (Arp134). Actually, Arp had been thinking in both directions all along. He discovered the association

in 1966. As far as I know, it was in 1968 that he first *operationalized* this way of thinking into a procedure.] Although there was no way of knowing at the time exactly where it would go, the study of these new associations was to lead to a complete revolution in our picture of the universe.

Over the next thirty years Arp and a few colleagues were to make an astonishing series of discoveries. These discoveries will be an essential part of the foundation for the next few centuries of scientific work, no matter what the academic community may think of them today.

It would require volumes to do justice to these findings [such as the paired ejection of quasars, Seyferts and BL Lac objects; that quantization occurs, not only on a subatomic, but on an intergalactic scale; the intrinsic redshift of newly created matter; and that the Abell clusters are part of our own paired galactic supercluster]; Arp's own books[3,4] are only a tightly compressed outline. Suffice it to say that the path Arp followed ultimately allowed him to see, through the telescope, the creation of new matter and to describe some of its properties. This creation involves the ejection of fantastic amounts of energy in paired jets from certain galaxies. At the end of these jets develop what Arp, using a metaphor from biology, calls "seeds," which then develop into new galaxies, quasars, and other types of astronomical objects.

By 1993 Arp was able to describe a new model of the observable universe, a particular version of continual creation [there were earlier, less satisfactory, models of continual creation, such as Hoyle's original "Steady State" theory], which satisfactorily replaces the "Big Bang." This challenged his own preconceptions and angered even some of his dearest colleagues, who were unable to follow him in this stage

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of his explorations (Reference 3, p. 157). Their reaction must have been a painful disappointment to him, but he preserved a good working relationship with them. To avoid embarrassing these colleagues or jeopardizing his access to X-ray telescope data, he held back from publishing his results for five years. Arp's new model, which is based on decades of careful research, is deeply moving and exciting. In his own words:

- ❑ The universe is not expanding, can be indefinitely large, and episodically unfolds itself from many points within itself.
- ❑ So far we can only be sure of seeing objects within our Local Supercluster (Virgo and Fornax). The distance to the next superclusters may be very large. We may be seeing only a tiny part of the universe.
- ❑ Conservation of mass-energy may apply for the whole, but it is not clear that it applies for the part we communicate with by light photons.
- ❑ Patterns in the seeds, which develop into new objects, must be imprinted from very complex laws in this indefinitely large universe. Objects are continually being born and growing but are somewhat different in each generation. (Reference 3, pp. 251-252)

Qualities of the True Scientist

It will be invaluable to identify some of the core qualities of the true scientist, as exemplified in the work of Halton Arp. It should be emphasized that these qualities cannot truly be separated from each other; they are only convenient labels for different aspects of a single whole:

1. The ability to identify and remove the obstacles to scientific understanding
2. Scientific curiosity
3. Judgment
4. Contact with spontaneous movement in nature
5. Persistence
6. Integrity

Arp deserves tremendous credit for leaping over the impediments erected by generations of academic thinkers, such as, "The Big Bang," "The Cosmological Constant," "The Expanding Universe," "The Swiss Cheese Universe," "Curved Spacetime," "Gravitational Lensing," "Dark Matter," "Empty Space," "Black Holes," "Colliding Galaxies," "Merger-Induced Star Formation," and so forth. Arp has painstakingly and explicitly shown each of these constructs to be an obstacle to our understanding of nature (Reference 3, pp. 270, 64, 68, 71, 254, 169, 30, 238, 14, 104, 105, respectively). To have correctly identified and eliminated even one of these obstacles is a scientific contribution of the first order. Most important has been his challenge to the mechanical application of the redshift-distance relationship. This one error has led academicians astray at every crucial decision point.

One can only marvel at the strength of Arp's focused *curiosity*, the depth of his longing simply to know the answers to two questions: What's out there? and What is it doing? This *scientific* curiosity goes hand in hand with functional thinking. It is very different from the "curiosity" of those who think mechanically or mystically.

The mechanist may crave "data" about the universe; much as a starving man craves food, he can never have enough. Nonetheless, he is "satisfied that he has penetrated to the heart of any matter when he has ranged it under one or other of his ready-made formulas."[5] Everything else is subordinated to these mechanical formulas, which he considers to be the "laws of the universe"; to him they are "God." The mystic, on the other hand, longs to contemplate the universe and to behold its grandeur, but sees it blurred behind a veil, "through a glass darkly." The God of the mystic is "unknowable." The functional thinker differs from both, renouncing the mechanist's sterile formulas and the mystic's blurred perception of "the oneness of it all." Instead, the functional thinker serves what Kipling called "the God of Things as They are."

An appreciation of the quality of sound judgment is vitally necessary to understand the sociological interactions between human beings in controversy, as well as the process of discovery in astrophysics. However, it is a quality that is so rare that few seem to know of its existence. Indeed, it is so uncommon that one praises it only at the risk of being misunderstood, because those who lack it may refuse to believe in its existence or importance. What Pericles said about the Little Man more than 2,300 years ago is as true today as it was then, just as true of the highly educated professor of astrophysics as it was of the Athenian mob:

> Praises spoken of others are only endured so far as each one thinks that he is himself also capable of doing any of the things he hears; but that which exceeds their own capacity men at once envy and disbelieve.[6]

For these reasons, I hope the reader will forgive me for belaboring the issue of *judgment*.

The popular image of the scientist is of one who "proves" his formulas with mathematical precision. It is not appreciated that the formulas are based on hotly debated assumptions whose accuracy depends on the scientist's judgment. A variant of this picture portrays the researcher proposing an experiment to "prove" his theory, the scientific community waiting anxiously for the results, and the disbelieving throng converted to the new faith like savages who witness a solar eclipse predicted by a missionary. [The most popular version of this scientific myth actually involves an eclipse, the one that "proved" Einstein's theory of curved spacetime in 1919.] Both of these images are based on a lack of appreciation of the importance of sound scientific judgment, which involves an understanding of the *qualities* of nature and cannot be reduced to numbers. Many modern scientists ignore this fact and attempt to avoid errors of judgment by using statistical analyses, but this only confuses matters more. As Arp points out:

> After the ritual argument about statistics is finished—is it 10^{-5} or 10^{-6}?—the argument is sufficiently abstract that people who wish to disbelieve the result can ignore it, when in fact it would be embarrassing to ignore it as a straight judgment call from looking at a picture. (Reference 3, p. 15)

Science is no different from any other great new endeavor in which a pioneer attempts to secure the cooperation and understanding of others who bring in an endless array of plausible viewpoints and "unanswerable reasons," most of which would only serve to lead the pioneer astray:

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> In the simplest situation there may be a hundred considerations which an ingenious mind can drag into the discussion; but even in the most complex situation there are seldom more than two or three which really matter. . .It is easy enough to say that good judgement consists in a firm grasp upon the two or three things that really matter; but it is one of the puzzles of human life how some people come at this and how others miss it. For of those who possess the gift of good judgement only a small minority seem to arrive at their conclusions by any conscious process of reasoning or selection. They seem rather to be guided by a kind of instinct, to be blessed with a fortunate blindness which fails to observe things that are only of secondary importance.[7]

The ability to *see* is one thing, but the instinct that leads one to *look* in the right place, avoiding the blind alleys, is quite another. An hour spent with a medium-sized amateur telescope will reveal a thousand fascinating objects in each little corner of the sky. Multiply that by a million to realize what the modern professional cosmologist is up against when he tries to decide which objects will lead, given our present state of scientific knowledge, to a deeper understanding of the universe as a whole.

Reading Arp's books, it is easy to underestimate his achievement because he (quite correctly) spares us the avalanche of contradictory data that his opponents in academia have accumulated in support of their theories. In addition, there are many other "alternative" theories brought forth by those who would challenge orthodox science, but who lack Arp's capacity for judgment. To understand the accomplishment of the pioneer who builds a city in the wilderness, we must compare him not only with the millions who stayed safe at home regarding the pioneer as crazy, but also with the hundreds of others who struck forth into the wilderness too, but left behind only burned wagons and decaying ghost towns.

The quality of being *able to make contact with spontaneous movement in nature* is just as necessary for the scientist as for the poet or the musician. A desire to make such contact is what leads many young people to express an interest in science. It is a rare individual who can preserve this quality through many years of academic scientific education, much of which is designed to train the student to understand nature as something static.

Early in his career Arp was drawn to the paired radio sources that were obviously being *ejected* from a common source. This shows he had both an intolerance of stasis and an ability to identify and study *observable*, fundamental examples of nature in motion. Arp's later discovery of the ejection of quasars from galaxies was too much for his fellow astronomers. Some colleagues could tolerate the heretical idea that the quasars might be "associated" with galaxies, but even the mention of the word "ejection" was enough to alienate them. In stark contrast to Arp's approach, current academic theories are based on *an intolerance of movement*. This is true despite the forced attempts, partly out of frustration or embarrassment, to compensate for the immobility of mechanistic cosmology. Fantasies of a "Big Bang" elaborated down to the first few microseconds are no substitute for contact with natural mobility. They are quite similar to the minutely elaborated pornographic fantasies of an impotent man.

As we shall see, Arp has shown tremendous *persistence* and *integrity* in carrying on his work, in the face not only of contempt and ridicule, but also of seemingly insurmountable obstacles thrown in his way by the academic community. A more personal manifestation of courage deserves to be acknowledged as well. Truly pioneering scientific work inevitably results in important gaps or loose ends, and Arp's work is no exception. [For example, there is no easy way to reconcile redshift quantization with the proper velocities of galaxies from expected gravitational forces. Another example is the evidence for a genuine redshift-distance relationship in the local supercluster, which cannot be understood given Arp's correct rejection of both the "expanding universe" and the "tired light" theory which is mechanistically based on "redshifting material."] The true scientist has, in his very blood, a passionate desire to understand the universe around him. Given this, it takes both persistence and integrity to see the gaps, tolerate *not knowing* the answer, and to continue working steadily on the things one *does* know.

The quality of being *able to make contact with spontaneous movement in nature* is just as necessary for the scientist as for the poet or the musician. A desire to make such contact is what leads many young people to express an interest in science. It is a rare individual who can preserve this quality through many years of academic scientific education, much of which is designed to train the student to understand nature as something static.

Arp and the Scientific Community

For thirty-five years Arp's work has been subjected to the contempt of many of his "colleagues." [Strictly speaking, when one expresses contempt for the work of others, one is no longer functioning as a colleague.] A scientific pioneer may be made of sterner stuff, but he is just as much, if not more, of a human being as anyone else and is not immune to the sting of ridicule or of misunderstanding. Such misunderstanding hurts all the more when it comes from previously sympathetic coworkers whom one has grown to respect. However, if ridicule is petty, painful, and annoying, impeding the work of a great soul can only be called murderous.

Part of the difference between the great man and the Little Man has to do with the issue Nietzsche raised: "Wie man wird, was man ist."[8] This means, roughly, "How one becomes what one is." Somehow the great man manages to "become what he is," in other words, to become what nature intended him to be, whereas the millions of Little Men around him do not. This process makes different demands on each individual: for Nietzsche it took years of working in obscurity and overcoming terrible physical pain; for Lincoln decades of wrestling with great social dilemmas in the legal and political arenas of a newly tamed frontier; for Alexander Hamilton a lifetime of working to ensure that his brilliant insights became part of the social structure of a newborn nation. Perhaps some day a biographer will be able to tell the story of how Halton Arp succeeded in "becoming who he is." We can guess that the story might include long nights spent on the great telescopes at Palomar and Las Campañas; waiting as many years as it took for each unexpected and thrilling discovery to reveal itself; overcoming his own preconceptions with each new discovery; and the prolonged

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There exists in the academic scientific community an observable tendency to kill scientific thinking, to kill scientific work and, in one sense, to "kill" prospective scientists.

Many bright and talented young minds are drawn to science, but choose another profession because they are "turned off" by the sterility and arrogance of modern mechanistic thinking.

and frustrating battles with increasingly prejudiced panels of anonymous scientific journal referees.

The great individual "becomes what he is" as a result of the work he undertakes. Love for this work enables him to overcome the Little Man in himself, for the simple reason that, if he acts and thinks as a Little Man, his work cannot proceed. In Arp's case this work is in cosmology, the science of the basic functions of the universe as manifested by large-scale phenomena. He developed the capacity in himself to make great leaps, as an individual scientist in the science of cosmology. However, it would be a mistake to imagine that such work can be done in isolation. Humans are uniquely social animals and every great work is a part of the social realm as it exists at the time. [That is, humans are the only animals who create new kinds of social structures; this is what Aristotle meant in his widely misinterpreted definition of man as a "political animal."]

The rigidification of science that began in the 1920s did not put a stop to the human impulse to work together in order to see better and farther. Even while the quality of scientific thinking and judgment declined, the technological (engineering) and sociological capacity to build exquisitely sensitive astronomical instruments continued to progress. Giant optical telescopes made it possible to discover quasars and their redshifts. Starting in the 1940s, radio telescopes opened a whole new world to astronomers. X-ray, gamma-ray, infrared, and optical telescopes have been launched into space. A major goal of most of these telescopes has been to "answer" cosmological questions.

At this point in the story of Arp's work we come up against an astounding sociological reality:

1. The astronomical community has been able to coordinate the efforts of thousands of human beings (hundreds of millions, if we count the governments that launch the rockets and the citizens who pay for them) to build and operate such instruments.

2. The same community was capable of producing only a single individual (plus a handful of people able to assist him) who could use the instruments for their most important purpose. It must be emphasized that when we say "could use the instruments," this includes not only the individual capacity for scientific thinking and judgment, but also the *social* capacity to establish, in accord with time-honored traditions and beyond any legitimate doubt, his right to the cooperation of others in the form of reasonable access to these instruments. This he did through decades of cooperative work and achievement *within* the scientific community.

A full examination of such sociological realities is beyond the scope of this article, but it is relevant to the story of Arp's work to point out the following: There exists in the academic scientific community an observable tendency to kill scientific thinking, to kill scientific work, and, in one sense, to "kill" prospective scientists.

Many bright and talented young minds are drawn to science, but choose another profession because they are "turned off" by the sterility and arrogance of modern mechanistic thinking. In such cases, we can say that, in a practical sense, the scientific community has "killed" prospective scientists, many of whom would have been valuable colleagues for someone like Arp. Cases where gifted young astronomers are "frozen out" of the profession are a more dramatic example. When other young astronomers who have a gift for cosmology choose narrower areas of study because they are unable or unwilling to live in a world of empty mathematical abstractions, then scientific work has been killed. When a massive flood of observational data is obtained and presented in such a way as to obscure the most obvious and important connections, then scientific thinking has been killed.

The fact that Halton Arp managed to survive these dangers, as a scientist, is a tribute to the human spirit and a genuine source of inspiration to us all. But that fact now brings us to the most painful part of the story: What happened to the man who "became what he is," namely the one person capable of fully using the great instruments of cosmological exploration. Around 1980, the two most senior Carnegie Institute astronomers on the committee that allocated time on the great telescopes at Palomar and Las Campañas were replaced by younger members. Then, in Arp's own words:

> I had tried to make a customary tennis date with an old and valued Caltech friend who had been a long-time opponent on the subject of quasars. He was embarrassed and evasive. On the following day, the six-person allocation committee, of which he was a member, sent me an unsigned letter stating that my research was judged to be without value and that they intended to refuse allocation of further observing time. In all honesty I must say that in my life the sun would never shine as brightly or the morning smell as fresh after this day.
>
> News of this denial of telescope time spread with amazing rapidity. A front-page article appeared in the *Los Angeles Times* based on the letter which had been released by the new director of my observatory upon the request of the newspaper. Soon, copies of that article and others on the same subject were hanging on bulletin boards of observatories all over the world. A number of directors of other observatories as well as other well-known astronomers communicated to the director of my observatory strongly supporting my research and opposing the action of the allocation committee. I challenged members of the committee to debate the actual scientific facts. But none of this prevented the inevitable last act. My observations on the 200-inch telescope at Palomar terminated in 1983, and at Las Campañas in 1984. (Reference 4, p. 167)

Given who Arp is, we can be sure that he is not just using a figure of speech when he says, "in my life the sun would never shine as brightly or the morning smell as fresh after this day."

In 1984 Arp went to the Max Planck Institut für Astrophysik in Munich on an Alexander Humboldt Senior Scientist award, and stayed on as a guest scientist. There he continued his work and made his greatest discoveries, many

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Even if full justice is done in the future for Arp's reputation, even if larger-than-life statues of him one day grace every observatory in the world, it will never replace a single one of the discoveries he was prevented from making.

of which were denied publication by all the major astronomical journals. To give just one example of the obstacles that Arp met at this point: An X-ray astronomer, Wolfgang Pietsch, discovered two intense X-ray sources close to and aligned across the active nucleus of the galaxy NGC4258. Arp found that these sources coincided with two blue stellar objects (BSOs) that he had photographed years earlier:

> At that instant I knew that the objects were almost certainly quasars, and once again experienced that euphoria that comes when you see a long way into a different future. In view of the obvious nature of these objects I felt Pietsch showed courage and scientific integrity in publishing the comment: "If the connection of these sources with the galaxy is real, they may be bipolar ejecta from the nucleus."
>
> Then the dance of evasion began. It was necessary to obtain optical spectra of the blue stellar candidates to confirm that they were quasars and ascertain their redshifts. A small amount of time was requested on the appropriate European telescope. It was turned down. Pietsch's eyes avoided mine when he said, "I guess I did not explain it clearly enough." The Director of the world's largest telescope in the U.S. requested a brief observation to get the redshifts. It was not done. The Director of the X-ray Institute requested confirmation. It was not done. Finally, after nearly two years, E. Margaret Burbidge with the relatively small 3 meter reflector on Mount Hamilton, on a winter night, against the night sky glow from San Jose, recorded the spectra of both quasars. It was fortunate that mandatory retirement had been abolished in the U.S. because by this time Margaret had over fifty years of observing experience.
>
> Of course, the referee report. . .was directed against her paper, which reported this important new observation. In her firm, but lady-like English way, Margaret withdrew her paper from the *Astrophysical Journal Letters* and submitted it to the European journal *Astronomy and Astrophysics Letters*.
>
> What was particularly appalling about this series of events was that Margaret Burbidge was someone who had given long and distinguished service to the scientific community: Professor at the University of California, Director of the Royal Greenwich Observatory and President of the American Association for the Advancement of Science among other contributions. It seems it was permissible to let her fly anywhere in the world doing onerous administrative tasks, but her scientific accomplishments were not to be accorded elementary scientific respect and fair treatment. (Reference 3, pp. 10-12)

In addition to the mistreatment of Pietsch and Burbidge, we can only imagine the degree to which Arp's own research was held up by incidents such as this one, where what should have been a quickly granted observation turned into a two-year ordeal.

It is only fitting that we pay a well-deserved and joyous tribute to the discoveries that Arp has given the world. We must also sadly acknowledge the many discoveries he was *prevented* from making, although we have no idea what they would have been. Even if full justice is done in the future for Arp's reputation, even if larger-than-life statues of him one day grace every observatory in the world, it will never replace a single one of the discoveries he was prevented from making.

I should like to close with a poem from Kipling: his vision of heaven for artists, whom he holds to a rather scientific standard. Like many visions of heaven, Kipling's calls attention to the exhausting frustrations of the great man's work, especially to how the Little Man, here on earth, frustrates the full development of life.

When Earth's last picture is painted and the tubes are twisted and dried,
When the oldest colours have faded, and the youngest critic has died
We shall rest, and, faith, we shall need it—lie down for an aeon or two,
Till the Master of All Good Workmen shall put us to work anew.
And those that were good shall be happy: they shall sit in a golden chair;
They shall splash at a ten-league canvas with brushes of comets' hair.
They shall find real saints to draw from—Magdalene, Peter, and Paul;
They shall work for an age at a sitting and never be tired at all!

And only The Master shall praise us, and only The Master shall blame;
And no one shall work for money, and no one shall work for fame,
But each for the joy of the working, and each, in his separate star,
Shall draw the Thing as he sees It for the God of Things as They are![9]

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About the Author

Dr. Robert Harman is a psychiatrist who practices medical orgone therapy in Belle Mead, New Jersey. He is assistant editor of the *Journal of Orgonomy* and member of the Board of Regents of the American College of Orgonomy.

*The American College of Orgonomy, P.O. Box 490, Princeton, NJ 08542; Phone: 732-821-1144; Fax: 732-821-0174; E-mail: aco@orgonomy.org; Website: www.orgonomy.org

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Aether Vacua and COLD FUSION

Frank J. Grimer*

The paper "The Diphase Concept, with Particular Reference to Concrete"[1] showed how the tensile failure of concrete depends on the pressure difference between the solid pressure and the fluid pressure on concrete specimens. What is normally described as "tensile failure" of concrete can be obtained, either paradoxically, by increasing the fluid pressure on the sides of the specimen, or conventionally, by decreasing the solid pressure on the ends of the specimen.

It is essential to be quite clear about how one must view the air pressure used to compress concrete to the point of "tensile" failure.

Once the existence of a substantial electromagnetic aether (β-atmosphere or β-aether) is accepted, then air pressure (α-atmosphere or α-aether) becomes a partial pressure of the β-aether. In failing the concrete by increasing the surrounding air pressure, we are—taking the broader view—failing the concrete by increasing the β-aether pressure. In other words the α-atmosphere is regarded as being dissolved in the β-atmosphere.

A comparison may be drawn with supplying pressurized air for a diver to breathe by increasing the pressure of helium (φ-aether, say). Just as helium comprises only 0.0005% of air and therefore exerts only a tiny fraction of normal atmospheric pressure, so also air, the α-atmosphere, comprises only a fraction of the space it inhabits and only exerts a tiny fraction of the β-atmosphere pressure.

Once the existence of the β-atmosphere—the β-aether—is accepted, then it is possible to make the Gestalt switch of seeing the concrete as a solid skeleton held together, not by internal tension but by external compression. More specifically, the concrete is held together by the difference between the relatively lower internal and the relatively higher external β-aether pressure.

In effect, one is moving the datum for viewing pressure in much the same way as one moves the temperature datum for viewing temperatures by using the Kelvin scale or moves the position datum by adopting the Helio-centric system.

Solid and Fluid Loading

The essential difference between solid and fluid loading is brought out best by considering the fracture patterns they generate with a concrete cube.

First though, it is necessary to eliminate certain preconceptions that engineers familiar with concrete testing may have about the pattern of failure conventionally generated in cube compression testing.

When a concrete cube is crushed between two steel platens, two unfractured pyramids are formed (Figure 1a). This has given rise to the erroneous idea that compression failure of concrete is a shear failure. It isn't.

Crushing concrete cubes, or 2:1 cylinders for that matter, between steel platens is a bastard test. As the concrete is compressed it tries to expand outwards under the platen, but is prevented from doing so by tremendous frictional forces which effectively puts the concrete in close proximity to the platens under tri-axial compression, thereby enhancing its local strength enormously. These frictional forces dissipate as one moves away from the platen and lead to failure of those unenhanced regions (Figure 1a).

However, if the compression test is carried out using Hilsdorf Brush platens, which are free to expand sideways with the concrete and consequently apply pure compression with no shear forces at the concrete steel interface, the following pattern of failure takes place (Figure 1b).

Numerous small vertical cracks open up in the surface of the concrete. These cracks grow as the platen pressure increases. The cracks grow until the cube is effectively broken up into a collection of columns (Figure 1c) by yz and xy fracture planes. As more planes develop, the columns become increasingly slender until the specimen fails through domino column instability (Figure 1d).

When solid loading is carried out by a compressive load unadulterated by shear, failure is by multiple fracture planes parallel to the compressive stress vector. This contrasts with fluid loading where fracture is manifest by a single fracture plane parallel to the compressive stress vector.

There are various ways of looking at the differences between solid and fluid loading and it is necessary to consider all of them in order to fully grasp what is happening.

First consider the failures in terms of feedback. Fluid loading exhibits positive feedback. When a region of the concrete surface begins to fail, the fluid rushes in and exerts a wedging effect on the concrete, pushing the walls of the crack apart.

Solid loading, on the other hand, exhibits negative feedback. When a region of concrete surface under the platen begins to give way, the platen bridges across the weak zone and throws more load onto stronger zones on either side.

A more subtle way of looking at solid and fluid loading is to think of both as being applied through a flexible membrane, the fluid loading membrane being far more flexible than the solid loading membrane. Thus the relative stiff-

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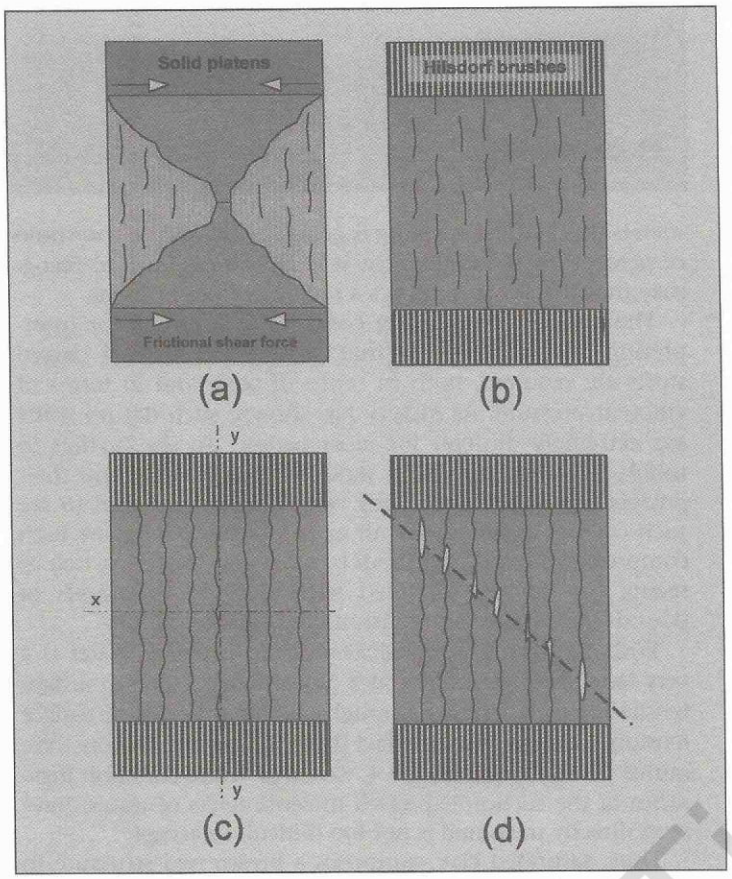
Figure 1. Cube failure under uni-axial compression.



ness of the flexible membrane becomes the determining factor in whether the loading is solid or fluid and the medium backing up the membrane can be the same in both cases.

Cracks and Cavities

There is a natural tendency to view the single horizontal fracture of the conventional tension test on concrete and the multiple vertical fractures of the conventional compression test as differing only numerically. In both cases the fractures fill with air which is at our ambient pressure datum.

However, there is a vital qualitative difference between the tension test single fracture and the compression test multiple fractures which is hidden from us by an anthropocentric viewpoint.

In the tension test our pressure datum—the ambient air pressure—is the same as the major pressure applied to the concrete, whereas in the compression test our pressure datum is the same as the minor pressure applied to the concrete.

By keeping to an absolute anthropocentric pressure datum we unwittingly switch our relative pressure datum between the two tests.

The pressure in the single fracture of the tension test is that of the major pressure applied to the concrete. For this reason the single fracture of the tension test is correctly described as a crack since it is preeminent in the same sense that a crack regiment is preeminent, say.

The pressure in the multiple fractures of the compression test, on the other hand, is that of the minor pressure applied to the concrete. These multiple fractures should not be described as cracks but as cavities, *i.e.* void spaces within a solid body.

This insight became obvious when carrying failure tests at all-around pressure as described in the "Di-Phase" paper.[1] Raising the ambient test pressure had the effect of removing our ambient pressure datum from within the experimental values to a point remote from them. This forced us to take a more objective view of the fracturing phenomena and recognize that not only were the single tension and multiple compression fractures different quantitatively but, and more importantly, they were also different qualitatively.

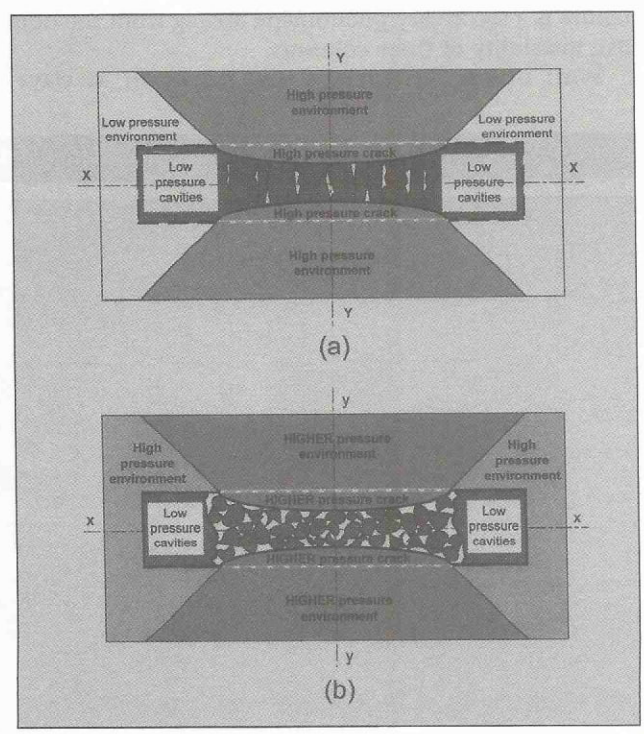
Ductile Failure at Upper Boundary Fluid Pressure

Consider now a bi-axial compression on a long square section concrete prism, as shown in Figure 2a. The compression is applied on the y and z axes by solid flexible frictionless platens. The boundary between the flexible platen and the concrete specimen is represented by a full line to indicate that the platen surface is impermeable to the high pressure. Both ends of the prism are open to the atmosphere in the x direction. The boundary between the atmosphere, the low pressure region, and the ends of the concrete specimen is represented by a broken line to indicate that the surface is permeable to the low pressure

Under the uni-axial loading considered previously, concrete fractures in the yz and yx planes form multiple columns prior to general instability failure. But this is biaxial loading, so the concrete only fractures along the yz plane, forming multiple rectangular plates prior to general instability failure.

These plates bulge and collapse to form heterogeneous rubble that is slowly squeezed out to the ambient pressure environment in the x direction. The cavities shown in Figure 2a are representative of the holes that form in this rubble, holes which are full of air at the same pressure as the region of relatively low pressure around the ends of the square concrete prism.

Figure 2. Prism failure under bi-axial compression.



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As for the regions of high pressure between the white dashed lines and the specimen surface, these are in fact cracks—very wide cracks to be sure, but cracks nevertheless. From a scientific viewpoint the essence of a crack is the incursion of the environment into the material, not the width of that incursion. If this seems like a highjack of the conventional meaning, it wouldn't be the first time and I don't suppose it will be the last.

Ductile Failure at Lower Boundary Fluid Pressure

To illustrate lower boundary ductile failure of concrete it is necessary to raise the pressures on the specimen, as shown in Figure 2b. The low pressure environment is raised to a high pressure and the high pressure environment is raised to an even higher pressure. The concrete rubble is now like rather coarse toothpaste that is being squeezed from the middle by the higher high pressure towards the ends which are at lower high pressure. [The important thing to note is that the cavities in the concrete rubble are at atmospheric pressure.]

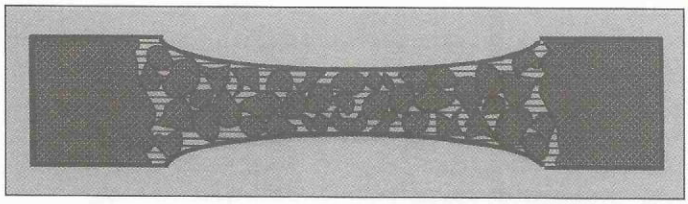
The high and the higher pressure environments are now brought together so that the specimen is subjected to a uniform all-around high pressure. The observer now moves his pressure datum to that high pressure. From his point of view the specimen (see Figure 3) now comprises a solid phase skeleton of concrete rubble (dark shading) in compression and a fluid phase musculature of cavities (horizontal cross-hatching) in tension. From the observer's point of view the specimen is an artificially prestressed concrete which has air as the 3D prestressing tendon.

Saturated Clay: A Model for Ductile Failure

Concrete is a useful material with which to obtain a clear understanding of the essential differences between brittle and ductile failure between cracks and cavities. Failure is scaled up to the macro scale, the human scale. One can readily see what is going on. In the standard compression test, for example, one can see the vertical cracks/cavities opening up and recognize that primary failure is cleavage into columns which span between the platens and that shear failure is a secondary phenomena arising from the domino-like instability of these columns.

With fine-grained ductile materials such as clays and metals this vertical cracking is generally below the threshold of perception. Consequently, it is all too easy not to recognize that the shear is always a secondary phenomena.

Figure 3. Specimen viewed from high pressure datum.



The problem with using concrete as a model for interpreting ductile failure is that gross psychological datum shifts are required, both in terms of scale and in terms of ambient pressure. As history has shown, such datum shifts are extremely difficult for most people. To see cavities in rubble as a fluid in a high state of tension is beyond their powers of imagination. They were taught in school to see such cavities as filled with air at 15 pounds per square inch compression. Expecting them to make the Gestalt switch of seeing the cavities as filled with fluid at thousands of pounds per square inch tension is asking too much.

With clay the psychological problem is eased. Water is a very tangible fluid and the idea of water being able to sustain tensile forces is familiar through the phenomena of surface tension. Consequently, the fact that the tensions of more than minus 100 atmospheres (pF 4, where pF is the common logarithm of the suction expressed in centimeters of water) have been directly measured is not too difficult to accept.

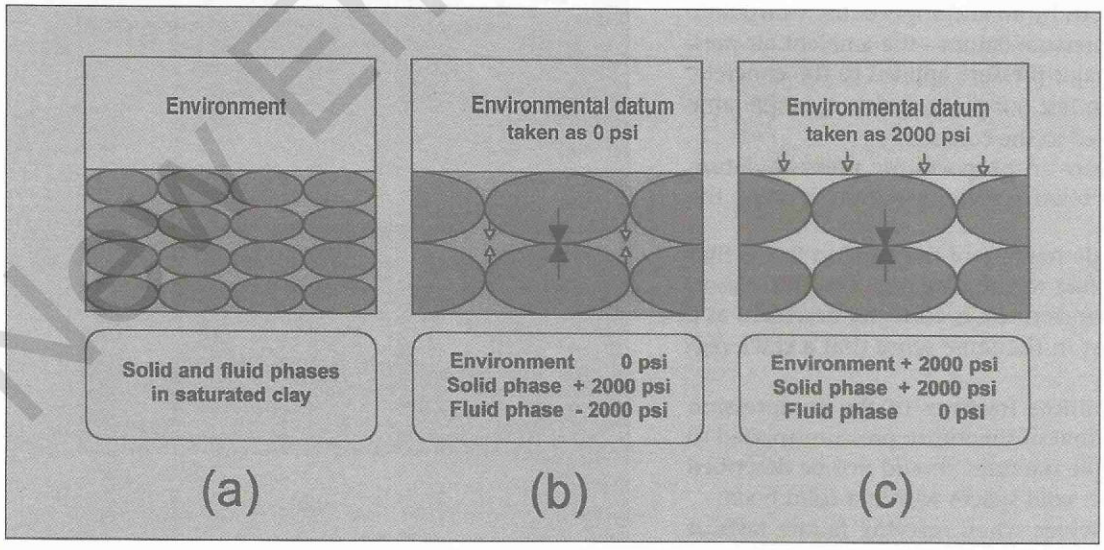
Thus, saturated clay comprises a prestressed structure in miniature. Nature has been doing from the dawn of time what man only consciously achieved in the last century.

An idealized view of the soil particle skeleton and its interaction with the pore fluid is given in Figure 4a. The conventional way of viewing the pressure relationship between the soil skeleton and the pore water is given in Figure 4b for an arithmetic compression/suction pressure of 2000 psi. In the conventional view the environmental atmospheric pressure is taken as the zero datum. This anthropomorphic datum is for pressure what the 0° Celsius datum is for temperature. In Figure 4c the datum has been shifted to the pore fluid. Viewed from this datum the soil particle skeleton is seen as being held together by the exterior β-atmosphere pressure—a Casimir type pressure operating on a very small scale.

In effect the water is recognized not to be in tension at all but merely under less compression than it would be if it were not hiding away within the soil particle caves.

The fact that free water is under an external compression of

Figure 4. Clay structure viewed from different pressure datums.



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some 3,700 atmospheres is supported by the equation of state for water discovered by the authors some three decades ago. Analysis of Bridgman's high-pressure tests on water showed that the relation between pressure and volume for water was of the form $P.V.^{-6}$ = a constant, P being the pressure from a physically significant datum, *i.e.* the applied pressure plus the 3,700 β-atmosphere pressure. The situation is analogous to that of Stefan's law for radiation, $E = \sigma.T^4$ where temperature is measured not from the anthropocentric datum of 0°C but from the physically significant datum of 0°K.

Since most readers will be unfamiliar with this equation of state for water, the accuracy of fit to Bridgman's data is given in Table 1 for a temperature of 20°C.

In order to fully appreciate the significance and scope of this equation of state for water the reader is recommended to get a copy of Bridgman's *The Physics of High Pressures*[2] and calculate the regression line fit for some of the other temperatures between 0 and 100°C.

Mild Steel: Ark of the β-aether Vacuum

Qualitatively, saturated clay and mild steel are similar in their ductile properties. The quantitative differences arise from their solid and fluid phases. In the case of clay, the two phases—clay mineral particles and water—are very familiar and easily separable. In the case of mild steel the solid phase corresponding to the soil particles is clear enough. It is that part of the elemental atoms which form the skeleton in compression. Precisely what fraction of the electronic structure are part of this skeleton and what part constitutes part of the pore fluid is not at all clear. However, whatever fraction of the steel fluid phase that is in tension relative to the steel solid phase is the fraction that constitutes the β-aether fluid which holds the steel solid skeleton together and is responsible for the strength of the naturally prestressed material.

At this point it is useful to partition the β-aether fluid phase into two, a liquid phase and a gas phase. When saturated clay is put under tension, the relatively incompressible water cavitates and the cavities fill with water vapor in equilibrium with the surrounding liquid water. The small cavities that form within the metal crystals of mild steel as cup and cone failure is approached may likewise be regarded as β-aether gas. It is known that these cavities coalesce to form the large lens-shaped cavity shown in Figure 5. This cavity contains the β-aether vacuum.

If the test is continued, the specimen eventually shears at an angle to the cavity axis to form the characteristic cup and cone ductile failure pattern.

Until now it has not been appreciated that the cup and cone pattern of failure is in fact very tangible evidence that the lens-shaped cavity contains a β-aether vacuum.

Consider the representational diagrams shown in Figure 6. The dark shaded circles represent the iron atoms within a crystal. The light shaded background represents the β-aether fluid. For ease of initial exposition the pressure datum will be take as the anthropocentric datum of zero external pressure.

Thus, as shown in Figure 6a, the solid particle skeleton will be in a state of compression (black arrows) and the β-aether fluid in a state of balancing compression.

As the cavity is formed (Figure 6b) the compression forces between the solid particles which come out of contact are lost. The tension forces, however, remain. But the total tension forces and the total compressive forces must balance. Consequently, as the cavity opens up, more and more compression force is thrown onto the particles at the edges of the cavity. Eventually the compressive strength of the annular edge is exceeded and the edge steel fails in shear with collapse of the β-aether vacuum together with a sound and light show.

Taking the pressure of the β-aether vacuum as the zero datum (Figure 6c) leads to an even easier interpretation. The

Table 1. Clay structure viewed from different pressure datums.

Applied pressure atm.	Effective pressure atm.	Measured volume	PV^{-6} volume	Difference
0	3610	1.0168	1.0183	-.0015
500	4110	0.9967	0.9969	-.0002
1000	4610	0.9780	0.9783	-.0003
1500	5110	0.9617	0.9619	-.0002
2000	5610	0.9472	0.9473	-.0001
2500	6110	0.9343	0.9342	+.0001
3000	6610	0.9225	0.9223	+.0002
3500	7110	0.9115	0.9113	+.0002
4000	7610	0.9012	0.9012	.0000
4500	8110	0.8919	0.8919	.0000
5000	8610	0.8832	0.8832	.0000
5500	9110	0.8750	0.8750	.0000
6000	9610	0.8674	0.8675	-.0001
6500	10110	0.8602	0.8602	.0000
7000	10610	0.8534	0.8535	-.0001
7500	11110	0.8469	0.8471	-.0002
8000	11610	0.8408	0.8410	-.0002
8500	12110	0.8351	0.8352	-.0001
9000	12610	0.8297	0.8297	.0000
9500	13110	0.8245	0.8244	+.0001
10000	13610	0.8196	0.8194	+.0002
10500	14110	0.8148	0.8146	+.0002
11000	14610	0.8101	0.8099	+.0002
11500	15110	0.8055	0.8055	.0000
12000	15610	0.8009	0.8012	-.0003

Figure 5. Ductile cup and cone failure of mild steel specimen.

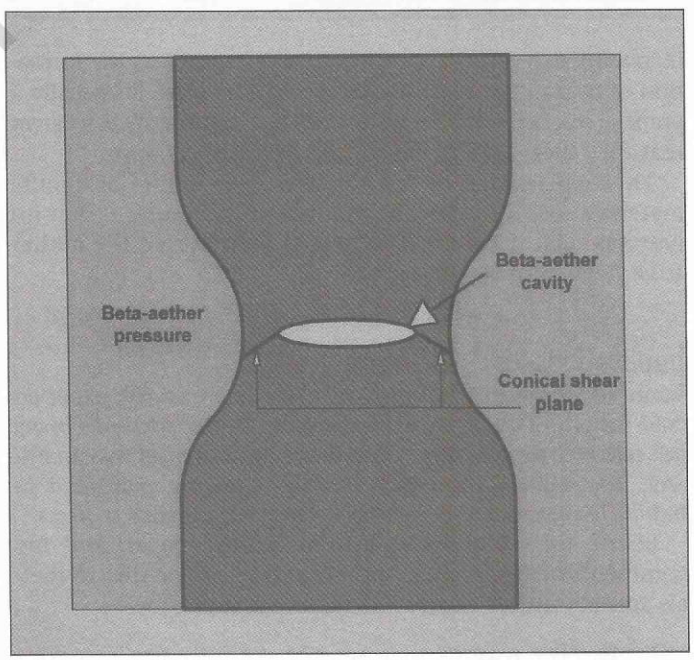

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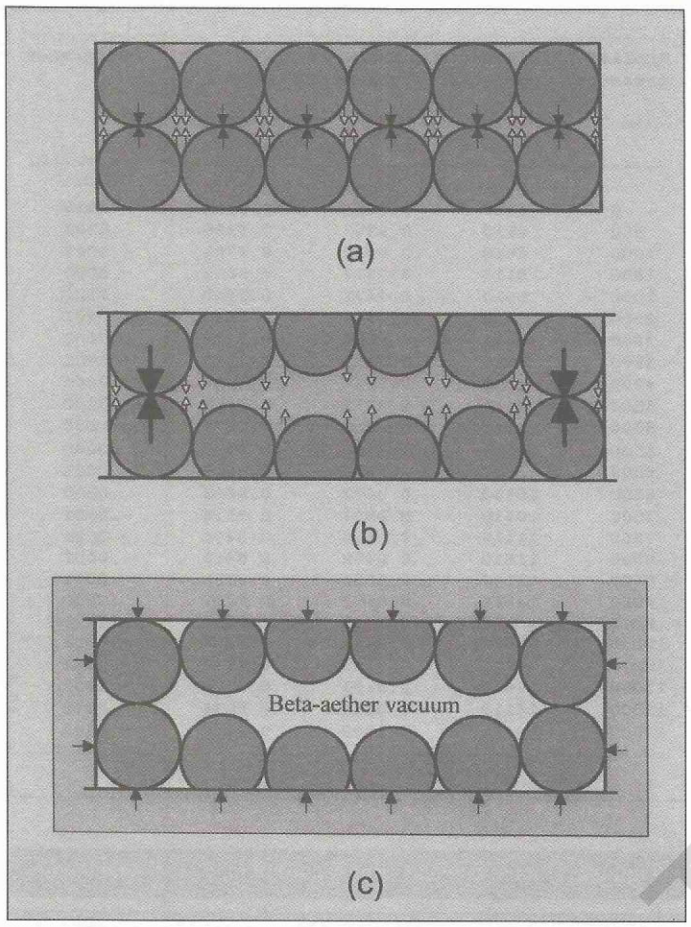
Figure 6. Development of Beta-aether vacuum in ductile failure cavity.



increasing external β-atmosphere pressure leads to the formation of two arches that steadily increase in span. Eventually a point is reached where the stress on the abutments is so great that they shear and the bridge and its invert collapse.

This explanation of the cup and cone failure of ductile materials seems so obvious that the only wonder is that no one has seen it before. The people who buried the aether alive have a lot to answer for.

Implications for Cold Fusion

Edmund Storms has written a very perceptive review paper on cold fusion.[3] The paper was submitted to *Rev. Modern Physics* but rejected, presumably because its subject matter was anathema. Fortunately the paper was subsequently published in *Infinite Energy*, which is more open minded on such matters.

Below are six quotations from Storms' paper, and my comments on the presumption that internal cavities in metals contain aether vacua. The italics are mine.

Quote: "For reasons that are not yet fully understood, certain batches of metal are much more likely to show the CANR [chemically assisted nuclear reactions] effects than are others."

Comment: Metal preparation is a relatively uncontrolled craft process, so the amount of internal micro cavitation is probably quite variable.

Quote: "Well over 100 explanations of CANR have been attempted, most of which have little relationship to reality or to being useful. However, several models do seem to offer important, partial insights into possible processes. Many of these models have continued to be changed and improved over the years. Unfortunately, most theories address the nuclear process *while ignoring the unique environment in which such reactions must occur*. In addition, most models still conflict with some observations within the field or rest on assumptions not supported by observations made outside the field."

Comment: This quote is particularly relevant because it refers to "the unique environment in which such reactions must occur." A β-aether vacuum is certainly that!

Quote: "Because the nuclear events occur in a variable number of random sites within the bulk material, a quantitative relationship between theory and observation is not yet possible even though some attempts have been made. No theory has explained why *only these rare sites are active* or has predicted their chemical characteristics except in general terms."

Comment: The reason that "only these rare sights are active" is presumably because aether vacua are only found at these sights. It would seem that it is the physical characteristic that is important, not the chemical characteristic.

Quote: "This behavior has prompted interest in the *effect of crack formation, so-called fractofusion*. Such an environment would be expected to produce 'hot' fusion caused by the high voltages produced therein. However, the required amount of tritium is not observed when neutrons are detected."

Comment: Shows that the possible importance of cavities is appreciated. What seems not to be appreciated is the vital distinction between cracks and cavities, and the existence of aether vacua in those cavities.

Quote: "Everyone can agree that a nuclear reaction involving coulomb barrier penetration does not occur within ordinary matter at any significant rate. The problem remains as to whether it can occur at all in *some rare and unusual environments*. Experience shows that a few materials have the capacity to contain these environments, *i.e.* to produce anomalous effects."

Comment: An aether vacuum of any significant size is certainly a "rare and unusual environment." So also is an atmospheric vacuum, in its own context.

Quote: "Understanding the nature of these isolated regions is fundamental to making this phenomenon occur at high levels and with predictability. *Such knowledge is also basic to any successful theory*."

Comment: It certainly is!

How can cracks filled with aether vacua possibly be midwife to cold fusion? That is the $64,000 question!

In all metals there are built-in stresses at a variety of scales. Some regions in the metal are in compression and some regions are in a balancing state of tension. Annealing can remove the large scale stresses, but the smallest scale stresses are intrinsic to the solid metal having any strength.

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Removing these micro-stresses, by heating to the melting point say, destroys that strength.

What happens if hydrogen nuclei are spat out from a high-pressure region into a low pressure region, like orange pips at a school dinner table? Would it be analogous to a temperature drop? Would the hydrogen nuclei condense? In other words, would they fuse?

If aether vacua are involved in the phenomena of cold fusion then researchers would be well advised not to apply significant stresses to the metals involved. This could conceivably lead to a gross acceleration in heat generation with possible disastrous consequences.

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1. Clayton, N. and Grimer, F. 1979. "The Diphase Concept, with Particular Reference to Concrete," in *Developments in Concrete Technology*, Vol. 1, F.D. Lydon, ed., Applied Science Publishers, England, pp. 283-318. From the paper's summary: The paradoxical behavior of a range of solids, including concrete, under certain unusual applied stress conditions is firstly described, followed by the attempt made by the original discoverer of the behavior to fit into a conventional theoretical framework. The authors then propose that a greater insight into material behavior, paradoxical or otherwise, can be achieved by adopting a diphase approach, the most important consequence of which is that materials owe their strength to an external source, in contrast to the traditional explanation of internal bonding. Experiments, on concrete specimens in particular, which demonstrate the reasonableness of this viewpoint are presented. It must be made clear, however, that experimental results, as such, can never provide coercive proof of the need to reject existing concepts; rather, this can only come about by a general recognition of the aesthetic and overall practical advantages of adopting a fresh viewpoint.
2. Bridgman, P.W. 1931. *The Physics of High Pressure*, Dover (Reprinted 1970).
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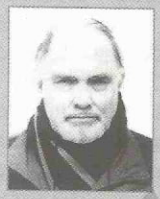
About the Author



Mr. Grimer received a B.Sc. in civil engineering from University College, London, in 1953, and received the Hounsfield Prize. In 1954 he was appointed as scientific officer in the Soil Mechanics Division of Road Research Laboratory (RRL), where he dedicated eight years to the research of the strength properties of clays and stabilized soils. He was appointed senior scientific officer in 1957. Mr. Grimer transferred to RRL's Structural Division of the Building Research Station in 1962, where he performed thirty years of research into lightweight concrete structural elements, concrete testing methods, and glass reinforced cement. He retired as principal scientific officer (Head of Structural Failure Section) in 1992. He has since been pursuing various scientific research interests.

*105 Draycott Avenue, Harrow HA3 0DA UK;
E-mail: f.grimer@grimer2.freeserve.co.uk

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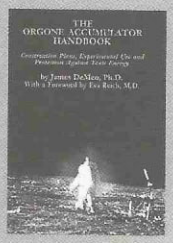

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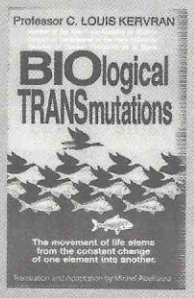

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Oil From Coal—FREE!

The Karrick LTC Process

Robert A. Nelson*

America has been called the "Saudi Arabia of Coal" because it contains some 28% of Earth's known reserves. Alaska alone contains over 6 trillion tons of coal. Coal accounts for 90% of our national energy reserves, but only about one-third of our energy consumption. Coal is a logical target of a national effort to achieve energy independence. The environmental hazards of burning coal limits its use in raw form. Fortunately there exists an elegant, proven method to produce synfuel and smokeless char from coal. It is a little-known process called Low Temperature Carbonization (LTC) that was perfected in the 1920s by Lewis Cass Karrick, who was an oil shale technologist at the U.S. Bureau of Mines.

Karrick-LTC (KLTC) is a pyrolysis process that involves heating coal, shale, lignite, or any other carbonaceous material with steam to about 800°F in the absence of oxygen. Oil is thus distilled from the material, rather than burning as it would if oxygen were present.

After treatment by the Karrick process, a ton of coal will yield up to a barrel of oil, 3,000 cu. ft. of rich fuel gas, and 1,500 lb. of solid smokeless char (semi-coke), depending on the type of coal that is used. The economics of the process are such that the oil is obtained literally for free! The smokeless char is an excellent substitute for coal in utility boilers, and for coking coal in steel smelters. It yields more heat than raw coal, and it can be converted to water gas. That gas can be converted to oil by the Fischer-Tropsch process. The coal gas produced by Karrick-LTC yields more BTUs than natural gas because it contains a greater amount of combined carbon, and there is less dilution of the combustion gases with water vapor. It can be fed directly to turbine generators to produce electricity. The waste tar is used by the chemical industry as feedstock for plastics. The Karrick process produces no pollutants other than carbon dioxide.

Electrical energy can be cogenerated at minimal cost, in addition to coal products. A Karrick-LTC plant with a daily capacity of 1,000 tons would produce enough steam to generate 100,000 KW-hours of electrical power at no extra cost other than the capital investment in electrical equipment and steam temperature losses in the turbines. No such claims can be made for any other coal or shale oil project in practice or theory.

Early in 1980, President Carter gained Congressional approval of a $20 billion synfuel program, including an Energy Mobilization Board to cut bureaucratic red tape and speed the approval of high-priority projects including plants to manufacture oil from coal and shale. The U.S.

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Department of Energy placed great emphasis on the Bergius process (direct liquefaction by hydrogenation) to produce synfuel. The Bergius process has been justly criticized by ecologists and economists; it is impossibly expensive, impractical, dangerous, consumes a lot of water, and its waste products pose a grave threat to the environment.

The Bergius process produces oil by combining heated hydrogen with coal under high pressure. The synthesis requires about 7,000 cu. ft. hydrogen per barrel of oil it produces, plus 1,500 cu. ft. of hydrogen per 1,000 cu. ft. of synfuel that it produces.

It is ironic that the major source of chemical hydrogen is natural gas. In terms of industrial chemical requirements and economics, natural gas has served this need well. But where hydrogen is considered as a means of conserving fossil fuels or producing synfuel, a much less costly and more abundant source must be found.

The Karrick process has been used with success in the industrial sector. The British National Coal Carbonizing Company (NCCC) produced smokeless char and oil with the Karrick process for forty years until the NCCC became catastrophically involved in North Sea oil in the 1970s. The company operated five Karrick-LTC retorts that produced Rexco-brand smokeless fuel (plus oil and gas) for use in England's official clean air zones. Other Karrick-LTC plants have been operated in Estonia and a few other countries.

Lewis Karrick did not invent LTC of coal; he perfected it. In America before 1860, more than fifty plants were extracting oil and gas from coal. Boston had five LTC plants that produced oil and gas for heat, light, axle grease, and paraffin. But by 1873, the surfeit of Rockefeller's then-cheap petroleum had forced the last coal-oil plant to shut down. Free enterprise could revive the art, for the Karrick process is most amenable to private enterprise initiative. Oiligarchists fear this possibility and have very nearly entirely suppressed this elegant technology. According to Webster, suppress means "to keep from public knowledge—to refrain from divulging."

In 1926, Secretary of Commerce Herbert Hoover (who later became President) made Karrick custodian of the government's coal-oil research data. Hoover advised Karrick to file patents, thus rendering the broadest public service and giving the government full credit. Sixteen patents were issued to Karrick outright. One, covering the underground distillation and gasification of coal and oil shale, was held jointly with his brother Samuel, and another with Douglas Gould. All of the patents have expired since then. Karrick died in 1962. The patents now are in the public domain.

As soon as Karrick and his associates proved they could produce oil from coal cheaper than the oil wells could pump it (plus gain major yield of gas and semi-coke), the government stopped all work on the processes at the pilot plants in Rifle, Colorado, and dismantled them.

The major companies that mined coking coal for use by the steel-smelting industry pressured the Bureau of Mines to suppress the Karrick process. It was feared that the cheap semi-coke char would replace coking coal and thus devalue hundreds of thousands of acres of coking coal reserves that are held by the coal-mining industry; that acreage is worth billions of dollars. Coking coal cannot be used for LTC processing because it agglomerates upon heating and plugs the retort. Coking coal comprises less than 5% of our national coal reserves and are in short supply. The other 95% are non-coking coals.

In 1926, Germany's I.G. Farben chemical combine announced the invention of the Bergius process for making synthetic liquid fuel from coal by hydrogenation. The German corporate directorate concluded that their best course of action was to cooperate with Standard Oil to develop the process, because it is so expensive and because (as Farben's president explained to a committee of the Reichstag), "The field of petroleum industry is so tremendous, and is so absolutely under the command of three large concerns, that the consideration of a new production in the fight against these concerns would have been very difficult. . .and the financial needs. . .beyond any expectation."

After months of talks between Karrick and patent broker Leo Ranney (and on the very day in 1929 that Standard Oil announced that it had paid $35 million for the Bergius process), Standard Oil offered Karrick the position of vice president and chief engineer, plus one-third of the stock in the "Oil & Gas Development Company." Karrick was to relinquish control of his patents and supporting data. Thus, the oil cartel was on the verge of controlling both methods of converting coal into oil: Bergius hydrogenation and Karrick LTC.

Federal anti-trust lawyers advised Karrick not to sign with Standard Oil. They believed that the cartel intended to suppress his patents until they had expired and the country had run out of oil. Only then would they implement Karrick's LTC technology—particularly the underground gasification of coal.

Karrick was advised to return to Utah to teach and develop his methods at the University of Utah. He founded the Utah Research Foundation for the endowment of the University of Utah, and several student theses were written about the research they developed. One of his students, S. Clark Jacobson, received the Mechanical Engineering Honor for the best undergraduate thesis of the year (1934) from the American Society of Mechanical Engineers.[1]

So-called experts have complained that a commercial-scale plant designed according to the principles established by Karrick would not be practical or mechanically feasible. Yet in fact, no difficulty whatsoever was encountered with the successful operation of the pilot plant built by Karrick and his students at the University of Utah.

A witness for the Bureau of Mines told the Senate Interior Affairs Committee that the Karrick retort is fundamentally different in construction and operation from any other design. The retort was used to process large amounts of bituminous material, and appeared to have the best record of performance of any available retort that had been developed. Every variety and mixture of shale available was used, and all types of charges were retorted successfully. The last run was made with the worst coking shale available. Although two-thirds of the spent shale was in the form of large clinkers, the retort was discharged easily. The KLTC retort is self-cleaning, has no moving parts, is automated, and is continuous feeding. It is also possible to make water-gas in the Karrick retort.[2]

In 1947, after completing commercial-scale runs on Appalachian coal, Karrick presented the Keynote address to the Convention of the Ohio Society of Professional Engineers:

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> Great coal-oil and shale-oil industries have existed and do now exist in foreign countries, and many successful plants have existed in the state of Ohio and other states. Recent studies have shown that oil from coals of Ohio can be manufactured by distillation, not hydrogenation, at less than the average price of petroleum. . .If the solid smokeless fuel residue from the LTC process was assumed to sell at the same price as the average price of prepared sizes of raw coal, then the cost of the crude oil would be zero dollars per barrel. This condition now exists in Ohio, and there can be made available plenty of low-cost fuel, excellently suited for domestic uses and industrial plants as a by-product of the manufacture of oil from coal. Also, the gas made from coal by these distillation methods is of about the same heating value as average natural gas.

The economic claims for Karrick-LTC coal-oil processes have been demonstrated on a commercial scale in England by the National Coal Carbonizing Co., Ltd., which manufactured the Rexco brand of char in its Snibston plant at Coalsville, Leicestershire. The NCCC developed five Karrick plants in Scotland and England, producing smokeless fuel for industrial and domestic use in England's official clean-air zones. The highly efficient plants carbonized 1,000 tons of coal daily, 750 tons of which is recovered as smokeless char. The NCCC's 35-ton capacity retorts also produced 3 million cubic feet of fuel gas and between 650-700 barrels of oil daily. No smoke or odor were discernible. The tars and phenol wastes were sold to the chemical industry as feedstock for plastics.

The conveying and processing part of the plant involved the services of three men and a supervisor per shift. All were easily trained from scratch. Adding a few more retorts in line would not have required any additional personnel. The plant was designed for six retorts, but the sixth was not installed because the British government limited NCCC's coal allocations. Unfortunately, NCCC became involved in Britain's North Sea oil project and was forced to cease its LTC operations in the 1980s due to political and economic machinations.[3]

Despite the incontrovertible example given by the NCCC, the official DOE position on LTC maintains the lie that "about 50% of the energy in feed coal remains in the total residue or char, and this residue is no better than the original."[4]

The DOE and oiligarchists discourage private enterprise and venture capital by issuing absurd, false statements about the technical and economical feasibility of Karrick's LTC technology. The DOE has suppressed the truth about the commercial capability of KLTC and its environmental advantages. The major oil companies, meanwhile, have been subsidized with billions of dollars to hydrogenate coal, even though the Bergius process and its variations will cost the public at least twice as much per barrel as OPEC charges.

Enter Harlan Trott, a staff member of the *Christian Science Monitor* for twenty years. He also served as chief of the *CSM's* San Francisco bureau. Trott met Lewis Karrick in 1949:

> Mr. Karrick was calling our home office, protesting and claiming that the Bureau of Mines was suppressing this technology, this cheaper and more efficient method to produce coal-oil. The editors picked me to talk with Mr. Karrick and see if we could sort out the facts. I thought it wouldn't take very long to do this, so I made arrangements for Mr. Karrick to come into the office around 3:30 in the afternoon there in Washington. I figured he'd be out of the way by four o'clock and I'd get ahead of the crowd going home to Alexandria. Mr. Karrick came in at the appointed time and we started talking. And then I suddenly noticed the city lights had come on and the office was deserted. We discovered it was about eight o'clock. I had been spellbound by this story he had to tell about oil from coal and the way he alleged it had been suppressed. We went out and had a quick bite to eat and came back to the office and talked until about 11:30 that night. And then I made a report, evaluated and sorted out the information, and suggested to the editors that we write a story about it. So the *Monitor* gave me about three months to concentrate and dig into this thing from all angles, and then we went to press and came out with a full-page copyright story in the March 20, 1950 issue of the *Christian Science Monitor*.[5-7]

The challenging story aroused so much controversy that the Bureau of Mines felt obliged to publish a 5,000-word statement, full of misinformation, in which emphatic mention was made of the alleged "high cost of first producing the high-temperature steam to be used in carbonizing the coal and then condensing it to recover the tar product."

On May 12, 1950, two months after the publication of Trott's article, Lewis Karrick set the record straight when he testified at a Congressional hearing on the future use of the Minnesota peat bogs as an energy resource:

> The simple and relatively inexpensive processes developed by me in the government service during the 1920s were designed for use as adjuncts to steam power plants so that there would be no need to invest new capital to produce steam. The LTC process would use off-peak steam from the power plant.
>
> When you heat coal just to the temperature we call "destructive distillation," oils form. If you don't let the temperature rise above that point, which is the same temperature used in cracking petroleum (700°-800°F), you get oil from coal, not tar.
>
> If the Bureau of Mines recognized this as oil instead of appearing dumb and calling it tar, then it should have been developed under the Synthetic Liquid Fuels Act. We can crack it into 50-odd percent gasoline, which is very good gasoline. It is better oil than you can get out of shale oil. It gives you as much oil per ton and gives you valuable by-products of smokeless fuel, which makes it cheaper than shale oil. So by not calling it oil, which it is if shale-oil is oil, its development has been obstructed.
>
> The present Bureau of Mines won't recognize this cheap source of oil. They will spend vast sums of money on the German methods, but not a cent on distilling oil out of coal by the way we made oil in the U.S. once.
>
> In fact, all the oil in the U.S. was made out of coal up to the time of the first oil well in 1859. There were 55 companies at one time, all listed in one of our government publications, manufacturing all of the oil used in the U.S., and it was not coal tar, it was oil!
>
> When I was in the shale oil work and had the title of shale oil technologist for the Bureau of Mines, we estimated that we could distill the oil shales underground and produce oil

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for a good deal less than a dollar a barrel, or if we used either of the two commercial plants that we built at Rifle, Colorado (1920-1926), we could make oil for $1.50 or $2 a barrel with either of those processes. Those are the figures, and we can prove it now. Since then, I have directed research at the School of Mines and Engineering in Utah for 8 years to prove these things, to offset information put out by the Bureau of Mines and others to the effect that you can't do it.

Capital costs would be somewhere around $2,000 to $2,500 per ton of daily capacity, present prices [1950]. When we first figured this back in the Bureau of Mines, way back in 1927 to 1930 when we finished this study, it was as low as $800.

Rocky Mountain coals. . .all yield from 35 to 45 gallons of oil per ton. You could get from 2,000 to 2,700 cubic feet of gas out of it, but we learned to heat until just the last trace of oil is out. Then it can't be made to smoke under any conditions. It burns with a very long, clear blue flame. The gas yields can be varied. The more gas you drive out of this smokeless fuel, the lower the BTU of the gas; so you can boost it up to 6,000 cubic feet of 800 BTU gas per ton of coal processed.

Then it was demonstrated that all of the solid smokeless fuel could be made into water-gas. In that case you could get about 40,000 cubic feet of 300 to 350 BTU gas from a ton of processed coal. And out of that water-gas you could make four barrels of oil by the Fischer synthesis process.
If you use some other gas such as hydrogen, rather than steam to distill oil from coal, that gas will be permanently mixed with the gas you make from coal and will make the new gas very low in BTU's and probably not salable. If you were to use a gas in place of steam, it would take power to compress the gas to force it to circulate through the coal. The power used to compress the hydrogen probably will be steam, and you would use nearly as much steam just to circulate the gas as you would if you used steam in the first place.

The thing to do is to distill the oil out of the coal, while making a smokeless fuel and high-BTU gas. In a national crisis you would quickly go to converting this reactive, solid smokeless fuel to oil. . .Those who have been using this smokeless fuel (i.e., industries and power plants) will then go to burning raw coal for the duration of the emergency. That's the way we think the national fuel economy ought to be handled. . .[8]

Even after such unarguable testimony, the Bureau of Mines refused to change its position, which defines coal-oil as tar.

Harlan Trott's article in the *Christian Science Monitor* was read by Hubert Humphrey, then freshman Senator from Minnesota. In testimony at a Congressional hearing in 1950, Humphrey stated that he had read Trott's article and discussed it with eminent scientists at the University of Minnesota and at the School of Mines at Rapid City, South Dakota. Humphrey said that he had come to be dissatisfied with the attitude that the Bureau of Mines held toward the Karrick LTC process:

Mr. Karrick believes that the merits of his cheap, domestic oil-from-coal process are unlikely to interest oil companies, or the Department of the Interior for that matter, until the companies run out of sources of cheap foreign oil.[9]

Shortly after the *Monitor* published the article, Trott received a hand-written note from Watson Snyder, who was the Justice Department's chief oil investigator, which stated: "The world oil cartel prevents the cheap production of oil from coal as it might bring about a reduction in prices in the U.S. . ."

In 1952, the government's suppression of the Karrick process precipitated a crisis of confidence within the Bureau of Mines. In an effort to clarify the technical controversy, Dr. Eugene Ayres, who was Director of Research of the Chemical Division of Gulf Oil and the foremost fuel economist on President Eisenhower's cartel-stacked Paley Commission, was invited to address the Bureau of Mines coal research staff over dinner at the Cosmos Club in Washington DC. Dr. Ayres proceeded to refute every point of the Bureau's position against Karrick's work:

The hydrogenation of coal is unnecessary and too expensive in terms of dollars and coal, and the process uses much precious water. About half of the thermal value of coal is destroyed in the Bergius process. Hydrogenation need not be used to any large extent in the future because there exist simple, continuous LTC techniques (such as the Bureau of Mines developed) in which moderate yields of oil are accompanied by major yield of char (smokeless fuel). The oil can be converted to liquid fuels while the char is an excellent fuel for steam boilers in electrical generating plants. The Karrick-LTC method—including the conversion of oil to motor fuel—destroys only 25% of the thermal value—half as much as the Bergius hydrogenation process.

According to Dr. E.R. Mellinger, a leading expert on LTC, the Karrick process has a cyclic efficiency higher than 90%.

In 1933, Germany imported 85% of its oil, but Hitler then instituted the most intensive synfuel program ever attempted. By the end of World War 2, Nazi Germany produced 75% of its own fuel by means of both the Bergius process and LTC of coal.

In 1945, the U.S. Technical Oil Mission went to Germany to study the Nazi's synfuel technology. Dr. Adolf Thau, who was Germany's leading expert on synfuel technology, told the mission that the Bergius process was "very expensive and accident-prone due to hydrogen explosions. . .Based on the coal introduced, only a very small amount of oil was obtained. Far better results were obtained by the simpler LTC methods." Dr. Thau produced a copy of a statement made in 1944 by British Minister of Fuels David George, disclosing that "oil from coal produced at home during the war had displaced fuel oil to a large extent in Great Britain. . .Further development of LTC is expected by the coal industry as a result of the experiences gained during the war, while the prospects for the hydrogenation of coal are judged less positively. . .The facts stated by the British government are fully confirmed by the experience gained in Germany."

Despite all the facts to the contrary, the DOE assiduously ignores the Karrick LTC process, preferring to issue false statements and fund a welfare program for technocrats:

A major emphasis. . .is being placed on the hydrogenation of coal because [the DOE believes] this type of process can produce the maximum yield of liquid fuel products.

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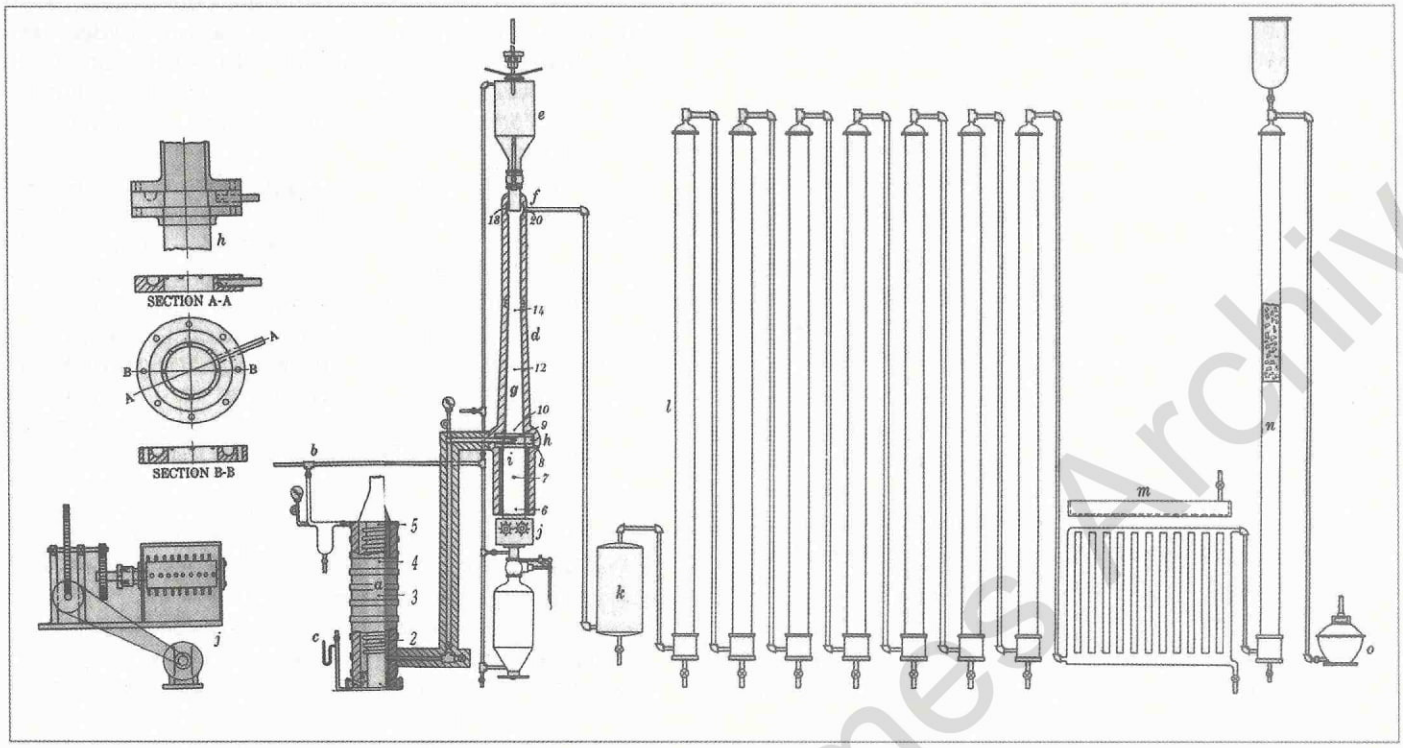

The schematic outlines much of the LTC process perfected by Karrick. He utilized steam power to make electricity as well as perform the functions of the oil-to-coal process.

> Hydrogenation promises to be the most efficient and economical means of making synfuel. . .

The Federal government built a $10 million, 30,000 barrel/day pilot plant to test the Bergius hydrogenation process, but the Secretary of the Interior ordered the plant dismantled in 1953, saying it was "useless to keep trying to get more than a quart of water in a quart jar." Yet again, in 1978, Congress awarded a $75 million grant to Gulf Oil Company for development of the Bergius process, which cannot be made to stand on its own financial feet. Much more public money has been wasted on the same folly since then. Oiligarchists insist that the public must subsidize the program, which only the largest corporations are sophisticated, experienced, and foolish enough to exploit in this pork-barrel fashion. The oil cartel finds it easy and profitable to obtain Federal funding for the Bergius process and related methods, rather than to institute the "free" Karrick-LTC technology.

During an interview with this writer in March 1980 at radio station KPFA (94.1 FM, Berkeley CA), Harlan Trott said: "You see, the threat here, to the oil cartel, is decentralization. Karrick-LTC lends to independent local control. Any co-op in this country wherever there's a coal mine can do this. In effect, every coal tipple can be an oil well."

To illustrate the point, Mr. Trott told of a group of merchants in Sydney, Australia (who cooperated during World War 2) to make shale oil to supply their needs. The group selected the Karrick-LTC process and purchased the 30-ton capacity retort developed by Karrick for the Santa Maria Railroad at Casmalia, California. The group began distilling oil from shale near Sydney, and they were so successful that they installed two more retorts without employing extra help. The co-op also developed adapters to allow the use of shale oil on their fleet of trucks. In England today, some trucks are operated by char-fueled steam power at one-fourth the cost of gasoline. During the 1930s, Karrick's students at the University of Utah drove their cars on gasoline made from coal in their campus pilot plant.

In 1979, one of Karrick's students, Biard Anderson, was interviewed on a TV program at the NBC studio in Salt Lake City. The moderator asked him about the possibility of cogenerating power with the Karrick process. Anderson replied:

> I can see that somebody like Utah Power and Light could take coal on its way to the generating plant, process and take the oil and gas out, and then send the smokeless coal on, and burn that. And I believe that they could sell the oil and gas at a profit. In other words, it could be that they can't afford to burn the raw coal anymore.

The Karrick patents have expired into the public domain. They can be used by anyone, and no one can monopolize them. The process is relatively inexpensive, and it does not need to be subsidized. The construction of a Karrick-LTC plant would cost only a quarter as much as a Bergius hydrogenation plant.

The technology lies dormant in the U.S., thanks to its suppression by oiligarchists. Let them eat coke! Give us "Oil for Free," thanks to Lewis Cass Karrick!

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U.S. Patent 1,894,691 (Cl. 202-7), January 7, 1933: "Destructive Distillation of Carbonaceous Material"

U.S. Patent 1,899,154 (Cl. 251-29), February 28, 1933: "Valve"

U.S. Patent 1,901,169 (Cl. 202-15), March 14, 1933: "Distillation of Carbonaceous Material"

U.S. Patent 1,901,170 (Cl. 48-206), March 14, 1933: "Gasification of Carbonaceous Material"

U.S. Patent 1,906,755 (Cl. 202-9), May 2, 1933: "Method of Improving the Properties of Solid Fuel by LTC"

U.S. Patent 1,913,395 (Cl. 262-1), "Underground Gasification of Carbonaceous Material-Bearing Substances"

U.S. Patent 1,919,636 (Cl. 262-1), July 25, 1933: "System of Mining Oil Shales"

U.S. Patent 1,923,213 (Cl. 203-3), August 1933: "Process & Apparatus for Carbonizing Coal"

U.S. Patent 1,938,596 (Cl. 202-221), December 12, 1933: "Retort"

U.S. Patent 1,942,650 (Cl. 202-17), January 9, 1934: "Apparatus for Coking Bituminous Coal"

U.S. Patent 1,945,530 (Cl. 202-16), February 16, 1934: "Destructive Distillation of Solid Carbonizable Material"

U.S. Patent 1,950,558 (Cl. 202-15), March 13, 1934: "Process for the Production of gas, Oil & Other Products"

U.S. Patent 1,958,918 (Cl. 202-15), May 15, 1934: "Process of Destructively Distilling Solid Carbonaceous Material"

U.S. Patent 2,011,054 (Cl. 202-6), August 13, 1935: "Process of Destructive Distillation of Carbonaceous Material"

U.S. Patent 2,268,989 (Cl. 202-15), January 6, 1942: "Process for Improving Fuel"

U.S. Patent 2,283,556 (Cl. 221-145), May 19, 1942: "Valve"

About the Author

Robert Nelson is the founder/operator of Rex Research, an archival service established in 1982 to collect and disseminate hard-to-find information about suppressed and dormant unconventional technologies.

*P.O. Box 19250, Jean, NV 89019
E-mail: alkemy618@aol.com
Website: www.rexresearch.com

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Compiled by Eugene Mallove

$1 Million New Energy Prize

We received the following enticing press release from an organization headed by Dr. Steven Greer. Let us all hope that the "Z-Prize" really *will* be won by December 31, 2002, but our experience suggests that it won't be. The goals and motivation for the prize are, however, most admirable.

COMPANY ANNOUNCES $1 MILLION ENERGY PRIZE

Press Release, September 30, 2002—Space Energy Access Systems, Inc. (SEAS) has announced the $1 million "Z-Prize" for an energy invention that would dramatically decrease the need for fossil fuels.

The Charlottesville, Virginia based energy company will provide the $1 million prize to the inventor or inventors who provide a testable prototype of an invention that can serve to either replace current internal combustion energy systems or greatly increase their efficiency. The Z-Prize is named after the so-called zero-point energy field that many physicists claim is a vast field of energy that can be tapped from the space around an object.

Specifically, the company is looking for new energy systems that could allow each home or business to have its own energy generation capability without the use of fossil fuels and a system for greatly increasing the fuel efficiency of motor vehicles. The winning invention must be reproducible, economically viable and suitable to widespread acceptance.

Steven M. Greer MD, the CEO of SEAS, states that: "We know such breakthroughs in energy generation have occurred in the past, only to be suppressed by a number of questionable means. This time, we are committed to identifying and bringing to the public the most advanced systems to replace our addiction to oil and fossil fuels."

SEAS has a Technical Advisory Board comprised of prominent scientists and engineers. Inventors may visit the SEAS website (http://www.SeasPower.com/zprizeannounced.htm) and complete an application. Submissions must be received by December 1, 2002 and the prize will be determined by December 31, 2002, unless the company determines that the contest needs to be extended.

"Known Laws of Physics and Chemistry" Enshrined:

BlackLight Power Loses Critical Appeals Court Battle with USPTO

New energy company BlackLight Power, Inc. of Cranbury, New Jersey, has lost an important appeal of a court case that could have significant implications for future new energy technology patents. In essence, the United States Court of Appeals for the Federal Circuit affirmed that it was proper for officials of the U.S. Patent and Trademark Office to withdraw a patent that had already been allowed (and was undergoing final routine processing), based on whether the so-called "known laws of physics and chemistry" were contrary to what the patent claimed. The text of the Court's decision, reproduced in full here, illuminates the critical issues that are at stake:

United States Court of Appeals for the Federal Circuit
00-1530
BLACKLIGHT POWER, INC., Plaintiff-Appellant,
v.
JAMES E. ROGAN, Director, Patent and Trademark Office,
Defendant-Appellee.

Appealed from: United States District Court for the District of Columbia—Judge Emmet G. Sullivan

DECIDED: June 28, 2002
Before NEWMAN, CLEVENGER, and SCHALL, Circuit Judges.

NEWMAN, Circuit Judge.

The question on appeal is whether the Director of the Patent and Trademark Office had the authority summarily to withdraw BlackLight's patent application from issue, following Notice of Allowance, payment of the issue fee and notification of the issue date, and with publication of the drawing and claim in the Official Gazette. We conclude that such withdrawal was within the scope of the Director's authority and responsibility for performing the mission of the Patent and Trademark Office, when viewed in light of the unusual circumstances of this case. The district court's judgment is affirmed.[1]

BACKGROUND

BlackLight Power Inc. conducts research into new sources of energy. BlackLight is the owner of United States Patent Application No. 09/009,294 entitled "Hydride Compounds." As described in BlackLight's brief, the inventions claimed in this and several related patent applications and an issued patent are directed to new energy technology derived from hydrogen compounds, and new compositions including conductive magnetic plastics and corrosion-resistant high-strength coatings.

During examination of the '294 application, the examiner initially rejected the claims on various grounds including operability under 35 U.S.C. §101 and enablement and definiteness under §112. After further prosecution including discussions of experimental results and the submission of samples, the examiner withdrew the rejection and allowed the claims. A Notice of Allowance was issued on October 18, 1999, the issue fee was paid, and issuance was noticed for February 29, 2000.

Another BlackLight patent application, entitled "Lower-Energy Hydrogen Methods and Structures," issued as United States Patent No. 6,024,935 on February 15, 2000. Shortly

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thereafter, *prompted by an outside inquiry*, [Note: All italics by *Infinite Energy*, for emphasis. Did the "outside inquiry" derive from an operative within the American Physical Society?—*EFM*] the Director of the Group that had examined these applications was made aware of both the '935 patent and the imminent issuance of the '294 application. *By Declaration filed in the district court, Group Director Kepplinger stated that upon reading the patent her "main concern was the proposition that the applicant was claiming the electron going to a lower orbital in a fashion that I knew was contrary to the known laws of physics and chemistry."* Director Kepplinger believed that the '935 patent and the '294 application were directed to similar subject matter, and contacted Robert Spar, Director of the Special Program Law Office in the Office of the Deputy Assistant Commissioner for Patents. Director Spar stated by Declaration that Director Kepplinger expressed concern that the '294 application "possibly had serious and substantial patentability problems and asked me to withdraw it from issue for further review."

On February 17, 2000 a Notice was issued to BlackLight, stating that the '294 application "is being withdrawn from issue pursuant to 37 C.F.R. 1.313. . .to permit reopening of prosecution. . .[as] requested by the Director, Special Program Law Office." It is undisputed that no one involved in the withdrawal had reviewed the '294 patent application before issuance of the Notice; at the argument of this appeal the PTO Solicitor stated that the application was not available for review because the file was in Pennsylvania for printing of the patent document.

BlackLight's attorneys made prompt inquiries about the withdrawal. The PTO treated the inquiries as a petition to the Commissioner requesting reversal of the withdrawal. On March 22, 2000 the petition was denied by decision of Assistant Deputy Commissioner Kunin. The decision stated that "[t]he PTO has an obligation to issue patents that meet the statutory requirements for patentability," and concluded that Director Kepplinger did not act improperly in obtaining withdrawal of the '294 application for further examination. The decision referred to Director Kepplinger's concern about the correctness of the scientific theory set forth in the issued '935 patent, described in the decision as "the discovery that energy was released by stimulating hydrogen atoms to relax, and, in so doing, to shrink to smaller radii, and to also attain energy levels below their 'ground state' according to a 'novel atomic model,'" and Director Kepplinger's belief that the '294 application was based on the same theory. The decision stated that Commissioner Kunin's inspection of the '294 application "reveals that this invention is asserted [*sic*] to matters containing fractional quantum numbers. Such fractional quantum numbers do not conform to the known laws of physics and chemistry." The decision did not further discuss patentability, but stated that the application would be returned to examination.

Meanwhile, on March 1, 2000 BlackLight filed suit against the PTO Commissioner (now denominated "Director") in the United States District Court for the District of Columbia, charging that the withdrawal was contrary to law and in violation of the Administrative Procedure Act, 5 U.S.C. §701 *et seq.* BlackLight argued that 35 U.S.C. §151 compels issuance when the issue fee has been paid:

> 35 U.S.C. §151. If it appears that applicant is entitled to a patent under the law, a written notice of allowance of the application shall be given or mailed to the applicant. The notice shall specify a sum, constituting the issue fee or a portion thereof, which shall be paid within three months thereafter.
>
> Upon payment of this sum the patent shall issue, but if payment is not timely made, the application shall be regarded as abandoned.

BlackLight argued that §151 does not allow for withdrawal of an application by the PTO after the issue fee has been paid, and that the PTO officials exceeded their authority when they withdrew the '294 application.

BlackLight also argued that 37 C.F.R. §1.313, the regulation cited by the PTO in withdrawing the application, violates the mandatory statutory language of §151:

> 37 C.F.R. §1.313
> (a) Application may be withdrawn from issue for further action at the initiative of the Office or upon petition by the applicant. . .
> (b) Once the issue fee has been paid, the Office will not withdraw the application from issue at its own initiative for any reason except:
> (1) A mistake on the part of the Office;
> (2) A violation of §1.56 or illegality in the application;
> (3) Unpatentability of one or more claims; or
> (4) For interference.

BlackLight stated that even if some form of withdrawal authority were deemed to exist as set forth in §1.313(b), the PTO exercised that authority in an arbitrary and capricious manner, for there had been no determination of unpatentability of any of the claims allowed in the '294 application.

The district court held that the PTO's interpretation of its statutory authority is entitled to deference in accordance with Chevron U.S.A., Inc. v. Natural Resources Defense Council, Inc., 467 U.S. 837, 842-44 (1984), and that the district court had so held in Harley v. Lehman, 981 F. Supp. 9 (D.D.C. 1997). The court concluded that the PTO's action in withdrawing from issue the '294 application (and subsequently four related applications) was "reasonable," reasoning that 37 C.F.R. §1.313(b) "functions as a last-chance procedural measure to observe the PTO's central mandate of issuing viable patents," and sustained the action of the PTO.

DISCUSSION

BlackLight argues that 35 U.S.C. §151 commands the PTO to issue the patent upon payment of the issue fee, pointing out that the second paragraph of §151 states that "the patent shall issue" upon payment of the fee. The PTO responds that §151 starts with the conditional clause: "If it appears that applicant is entitled to a patent under the law. . ."

We agree with the PTO that while the words "shall issue" indeed impose a duty, the preface to §151 places a condition on that duty. This preface conditions not only the issuance of the notice of allowance but also the ensuing steps of §151. Statutory interpretation is "not guided by a single sentence or member of a sentence, but look[s] to the provisions of the whole law, and to its object and policy." Dole v. United Steelworkers of Am., 494 U.S. 26, 35 (1990) (internal citations omitted).

Both paragraphs of §151 together define the obligations and procedures of the notice of allowance and issuance. Section

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151 does not prohibit the Office from interrupting the sequence if the condition set forth in the opening clause is reasonably believed not to have been met. Correct statutory interpretation is that which is "most harmonious with [the statutory] scheme and with the general purposes that Congress manifested." Commissioner v. Engle, 464 U.S. 206, 217 (1984) (internal citations omitted). We conclude that §151 does not prohibit withdrawal by the PTO of a patent application after the issue fee has been paid.

BlackLight states that even if the PTO has statutory authority to withdraw applications, such withdrawal is limited to the grounds specified in the implementing rule, 37 C.F.R. §1.313(b). BlackLight argues that none of these grounds applied, and specifically that ground (3), "unpatentability of one or more claims," requires a determination of unpatentability before the provision can be invoked, and not a mere hint or suspicion. The district court held that §1.313(b)(3) did not require a "final pronouncement" of unpatentability at the time of withdrawal.

The object and policy of the patent law require issuance of valid patents. This responsibility, and the mission of the PTO, require authority to implement §151 by taking extraordinary action to withdraw a patent from issue when a responsible PTO official reasonably believes that the subject matter may be unpatentable and that the application may have been allowed in error. The complexity of the examination process, and the potential for error in any human activity, weigh on the side of according the PTO latitude to withdraw an application from issue without a final determination of unpatentability when the exigencies of time do not allow for such determination.

The decision to withdraw the application was made by PTO officials acting within their authority and in fulfillment of their obligation to assure that patents are properly examined, and valid. In Skidmore v. Swift & Co., 323 U.S. 134, 139-40 (1944) the Court observed that agency actions are entitled to judicial respect when they are reasonably taken and in accordance with the "specialized experience" of agency officials and the "validity of its reasoning." Director Kepplinger, who is presumed to be knowledgeable in the fields of physics and chemistry, upon review of the '935 patent and being generally advised of the scope of the '294 application, reasonably believed that the '294 application had not been adequately examined, and took the only available action to return the '294 application to examination. That summary action was reasonably within the scope of the agency's authority and was not an arbitrary or capricious action. In Baltimore & Ohio Railroad Co. v. United States, 386 U.S. 372, 421 (1967) Justice Brennan remarked, in concurrence, on "the importance of leaving great flexibility with the agency to deal with emergency situations" in order to avoid harming that which the agency oversees. Such action must of course be reasonable under the circumstances and rare in occurrence, lest the emergency become the rule. But when necessary in order to fulfill the PTO's mission, with safeguards to the interests of the applicant including fair and expeditious further examination, we agree with the district court that the action taken is a permissible implementation of the statute and regulation.

The PTO's responsibility for issuing sound and reliable patents is critical to the nation. It has not been shown that the PTO's exigent action was unreasonable in view of the scientific concerns of the Group Director and the imminent issuance of the patent. In re: Alappat, 33 F.3d 1526, 1535, 31 USPQ2d 1545, 1550 (Fed. Cir. 1994) (en banc) this court sustained extraordinary action when the Commissioner in good faith believed that such action was required to ensure the issuance of valid patents, observing that "the Commissioner has an obligation to refuse to grant a patent if he believes that doing so would be contrary to law."

The judgment of the district court is affirmed. No costs. **AFFIRMED.**

Reference

1. BlackLight Power, Inc. v. Dickinson, 109 F. Supp.2d 44, 55 USPQ2d 1812 (D.D.C. 2000).

No "Genius Awards" to Science Heretics?

In late September, the John D. and Catherine T. MacArthur Foundation announced the twenty-four winners of the 2002 MacArthur Foundation "genius grants," each a no-strings-attached award of $500,000. According to an Associated Press story, Jonathan Fanton, president of the MacArthur Foundation, remarked: "In all our programs, we are committed to nurturing those who are a source of new knowledge and ideas, have the courage to challenge inherited orthodoxies and to take intellectual, scientific, and cultural risks." We at *Infinite Energy* are not aware of *any* new energy researcher or physics heretic who has ever won a MacArthur award. Perhaps some day. . .

Tilley Device Update

The last issue of *Infinite Energy* (p. 69) contained a short "breaking news" account of the very large claims of inventor Carl Tilley, who was attempting to demonstrate his "free energy" technology by powering a car at the Nashville, Tennessee Superspeedway. Mechanical failure interrupted that demonstration, as we reported. The Tilley website now makes this new promise:

> "The Tilley Foundation just took delivery of this new SUV to convert to a fully electric vehicle to drive along with the DeLorean during their next demonstration. This vehicle was chosen to provide clear evidence that any of today's popular vehicles can function with electric motors and battery banks kept charged with the TEV device.
>
> "This SUV is a 5 speed stick with 4 wheel drive. The conversion process will not change the outward appearance or the interior functionality in any way, for all intents and purposes (save the power plant) it will be like any other Xterra on the road.
>
> "Another test run for Validation is set for less than 30 days, hopefully from today (9-15-2002). We expect to also run the new SUV that will be converted to all electric with our device along with a Golf Cart and an Electric Bicycle. The test will most likely be on the Interstate at normal speeds of 65 to 70 miles per hour. We expect to run at least 400 miles on only 12 off the shelf type batteries the golf cart will be held at a different location being tested by another independent group for verification.
>
> "A list of who will perform the validation test will be provided.

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"We discovered that in addition to our bearing problem on the left side that on the right side the transmission axle was hitting the top of the car frame on the curves at 96 mph and was cutting the shaft. These problems have been corrected but we will not do this race track thing for test. . .normal cars are just not set up for race track driving. . .a lesson quickly learned.

"We have encountered some stiff opposition to stop this project. . .however, no matter what, it will be completed. . .I do not accept intimidation, threats, or other attempts very well and it just makes me more determined than ever to get this product out and prove it."

Moller Skycar Enters Alliance with ZAP

Vertical Takeoff and Landing Aircraft Manufacturer Teams with Electrical Vehicle Pioneer to Develop Future Products

PRESS RELEASE, DAVIS, CA, October 14, 2002—Moller International and advanced transportation developer ZAP ("Zero Air Pollution") announced today that they have signed an agreement to jointly develop new transportation products.

New products under consideration will use technology developed for the Moller M400 Skycar, and the company's ultra-low emissions, alternative fuel-compatible rotary engine technology. ZAP, which makes electric scooters, bicycles, and other forms of advanced transportation, intends to assist Moller by working with its manufacturing partners to explore possibilities for production of the Skycar and other technologies that meet the two companies' goals for quality and affordability.

Moller International (http://www.moller.com) was formed in 1983 and is the developer of the Skycar, a four-person Vertical Takeoff and Landing Aircraft currently undergoing initial flight-testing. The Skycar has the ability to provide an airborne alternative to 85% of the miles now traveled by automobiles. The company is a research and development firm working on new technologies in the field of aeronautics. Moller International has invested more than one million labor hours into the development of the specialized technology in the Skycar.

ZAP (http://www.zapworld.com) was founded in 1994 to develop and commercialize transportation alternatives using the latest in electric technologies and has delivered more than 75,000 vehicles to customers worldwide. Its core group of founders has over fifty years of experience in electric transportation with the goal to provide efficient transportation that people all over the world can afford. The company believes that the future of the environment depends on bringing these new technologies to the world's emerging economies.

For further information about the Moller Skycar, visit either of the websites noted above or call Moller at 1-530-756-5086 or ZAP at 1-800-251-4555.

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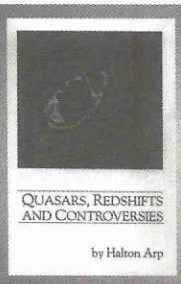
Against the Grain: Anti-Big Bang Books Reviewed

Reviews by Eugene F. Mallove



Quasars, Redshifts, and Controversies

by Halton Arp
ISBN 0-941325-00-8
Hardcover, 198 pp., Out of Print
Interstellar Media, 1987

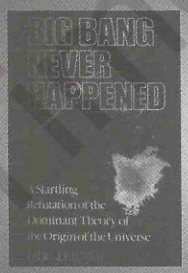
Journalist Eliot Marshall pondered the plight of "researchers with maverick ideas" in "Science Beyond the Pale," bannered in the "News and Comment" section of *Science* (July 6, 1990). He took special note of investigators in space physics, such as the author of this book, astronomer Halton Arp, who "find themselves fighting an uphill battle for acceptance. . ." In 1990, cold fusion was but the latest victim of scientific orthodoxy; Marshall's essay mentioned it briefly, quoting Park that cold fusion was "preposterous to begin with" and that "most screwy ideas turn out to be just screwy ideas."

Of course, cold fusion did indeed seem incredible at first—a possible laboratory mistake—until the overwhelming confirming evidence for nuclear-scale excess heat and nuclear products came in steadily but surely. Yet to the scientific establishment, all this evidence has been meaningless—to it, nothing has changed; cold fusion is still a "screwy idea."

Now, switch from the laboratory to the macrocosm. If one had never heard of the "Big Bang" and had then learned about it, the theory would indeed seem "screwy." The Big Bang asserts that all of matter and energy, in fact all of "space-time" itself—supposedly *everything* there in the Universe—popped into existence from a tiny quantum of "nothingness" much smaller than a pin-point, about twelve to fifteen billion years ago. Yet the evidence against this peculiar idea is quite spectacular and broad, as other articles in this issue of *Infinite Energy* attest. But the Big Bang is not considered to be a "screwy idea" by the establishment; it has in fact become its darling, its creation myth. Indeed, the cult of the Big Bang has become a veritable religion, whose pillars must be defended at all cost.

The publication of *Quasars, Redshifts, and Controversies* in 1987, by then already outcast astronomer Halton Arp, was a loud and very precise shot fired against the Big Bang. This work is a tightly argued, easily understood presentation of the evidence against reigning paradigm that the high redshift of quasar light places these peculiar objects (which have been known only since 1963) at vast cosmological distances—*not* in association with nearer galaxies. The photographic and other evidence that Arp so lucidly presents casts doubt on the very basis of the so-called expanding universe (and therefore the very foundation of the Big Bang). It calls into question the very meaning of the redshift of the light of distant objects. The evidence suggests profoundly unusual matter creation physics at work in distant parts of the universe.

But the larger message from Arp is this: "I am sure emotions will be stirred as a result of my comments in this book. That, I am willing to endure, because I feel that the way in which research is conducted is one of the most crucial of mankind's activities. If the research is imaginative and accurate, and the human relations promote and protect this process, then the results will inevitably be worthwhile. If the process is biased, the practitioners too hostile or competitive for personal gain, or lacking in the critical element of sportsmanship, then the results will inevitably be delayed and distorted." Sad to say, Arp's warning of 1987 was not taken seriously by the establishment; it is violated routinely.



The Big Bang Never Happened

by Eric Lerner
ISBN 0-8129-1853-3
$21.95 Paperback, 466 pp.
Times Books/Random House, 1991

In 1991, plasma physicist Eric J. Lerner's book became the highest profile challenge in the popular press to the Big Bang. The *New York Times* even allowed Lerner space to challenge the Big Bang, in an Op-Ed column, "For Whom the Bang Tolls" (June 3, 1991, p. A17). He wrote, "The Big Bang Theory is crumbling as Ptolemy's earth-centered cosmos did [400 years ago], but many of my colleagues refuse to believe it. . .The pessimistic Big Bang may be replaced with a universe evolving from a past without beginning to an unlimited future."

Well, though he was eminently correct in his critique of the Big Bang, he misjudged the inertia of the scientific establishment. Big Bang mythology has *not* crumbled over the past decade. In the November 1991 issue of *Sky and Telescope*, that prestigious magazine's gold-covered 50th Anniversary issue, I had the privilege of reviewing Lerner's book—from the perspective of my then erroneous belief in the Big Bang theory: ". . .Lerner takes what may be the best shot yet at the reigning Big Bang cosmology, but he fails to provide adequate evidence against the idea that time and space had a beginning some fifteen billion years ago. Still, he has produced a very interesting account that will provoke gasps at his artful climb up a vertical cliff to prove that the universe never had a beginning and will have no end. If by some improbability the Big Bang concept ever is replaced by

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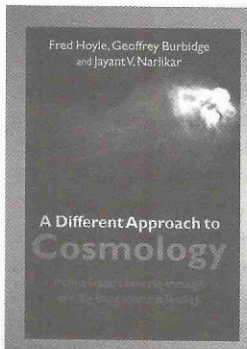
another 'Big Idea,' this work will be remembered as the voice in the wilderness that was right in its intent, if not its suggested mechanism."

My view in 2002 is that Lerner was right on target in his criticism of the Big Bang! My negative review of 1991 was very misguided by my then misunderstanding of how the contemporary scientific process works to filter out "unacceptable science." I hereby apologize for my erroneous criticism. Lerner and late Nobel laureate Hans Alfvén advocate a "plasma cosmology," in which gravity plays almost no role in the larger structure of the universe. That may or may not be correct, but it is worthwhile to read Lerner's book to find out what this paradigm has to offer. I should note that the November 1991 issue of *Sky and Telescope* in which my review of Lerner's book appeared was signed, "An astronautical engineer and lecturer in science journalism at MIT, Mallove wrote the book *Fire from Ice*, about the cold fusion furor." Yes, that was the beginning of wisdom.



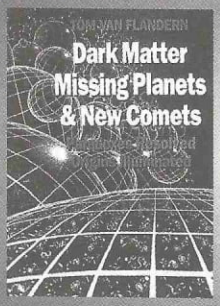
A Different Approach to Cosmology: From a Static Universe Through the Big Bang Towards Reality

by Fred Hoyle, Geoffrey Burbidge, Jayant Narlikar
ISBN 0-521-66223-0
$65.00 Hardcover, 357 pp.
Cambridge University Press, 2000

This is a landmark work for the technically inclined in cosmology, yet its language and presentation is very clear—making it understandable to a range of readers conversant with cosmological terminology. It tells the truth about the uncertainties of modern cosmology and points to directions in thinking about the cosmos that are contrary to the Big Bang.

The lead author, astronomer Fred Hoyle, died last year at age 86, after a distinguished and often controversial career in science. In an obituary in *Nature*, John Maddox, emeritus editor of that bastion of skepticism against frontier ideas in science, bowed to Hoyle's antagonism to the Big Bang. He offered praise to *A Different Approach to Cosmology*: "This is a scholarly rather than a polemical work, in that it is a well-documented guide to extragalactic evidence against the Big Bang (a term incidentally, intended to be derisive, that was coined by Hoyle himself in a broadcast lecture of 1952). My own conviction is that Hoyle's skepticism was well-founded. But it is too soon to tell how the Big Bang will be replaced by some other cosmology. That is heterodoxy."

Hoyle in 1948 became the author of steady-state cosmology, a concept championed independently by Herman Bondi and Thomas Gold. This described a universe that always would look to observers roughly the same at all cosmic times—through the eternal creation of new matter in between the galaxies of an expanding space-time plenum. Hoyle and his co-authors later championed what they would call the "quasi-steady state" theory. In this theory, creation of new matter occurs in "little bangs" (or "mini-creation events") in the cores of galaxies—matter that is ejected from galactic nuclei as quasars. Thus, we find how congenial is the work of these authors to the pioneering observations of Halton Arp.



Dark Matter, Missing Planets, and New Comets: Paradoxes Resolved, Origins Illuminated

by Tom Van Flandern
ISBN 1-55643-155-4
$22.50 Paperback, 514 pp.
North Atlantic Books, 1993

This book by former U.S. Naval Observatory astronomer Tom Van Flandern is far broader in its coverage of astronomical heresies than problems with the Big Bang—though this is an important part of the book. It is a *must read* for those who would like to understand the evolution of a heretic astronomer away from his earlier establishment opinions. Tom Van Flandern's latest views on the Big Bang are gathered in his definitive article in this issue of *Infinite Energy* (p. 10), but his synopsis in Chapter 22 of this 1993 book does not need to be changed: "Despite the widespread acceptance of the Big Bang theory as a working model for interpreting new findings, not a single important prediction of the theory has yet been confirmed, and substantial evidence has accumulated against it. Here we examine the evidence for the most fundamental postulate of the Big Bang, the expansion of the universe. We conclude that the evidence does not support the theory; and that it is time to stop patching up the theory to keep it viable, and to consider fundamentally new working models for the origin and nature of the universe, in better agreement with the observations."

There is probably no more interesting and important book in all of astronomy today than this monumental creative work. [Available from *Infinite Energy*—www.infinite-energy.com]

Bye Bye Big Bang, Hello Reality

by William C. Mitchell
ISBN 0-9643188-1-4
$19.95 Paperback, 448 pp.
Cosmic Sense Books, 2002

This is a very accessible, well-organized, and enjoyable tour of all the open questions about the Big Bang theory—challenges to a prevailing dogma that continue to be swept under the rug by a self-satisfied scientific establish-

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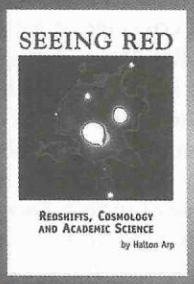
ment. It contains many outstanding quotations from participants on both sides of the little-known Big Bang controversy. One by noted astronomer Geoffrey Burbidge sums up the author's thesis: "Big Bang cosmology is probably as widely believed as has been any theory in the history of Western civilization. It rests, however, on many untested, and in some cases untestable assumptions. Indeed the big bang cosmology has become a bandwagon of thought that reflects faith as much as objective truth. . ."

Author Mitchell writes from the perspective of an accomplished engineer who has seen through the ingeniously constructed fantasies of the Big Bang physicists. The book features several excellent appendices on relativity, particle physics, quantum theory, the latest "fantasies" of theoretical physics, and, a compendium of very basic calculations pertinent to cosmology. [Available from *Infinite Energy*—www.infinite-energy.com]



Seeing Red: Redshifts, Cosmology, and Academic Science

by Halton Arp
ISBN 0-9683689-0-5
$25.00 Paperback, 306 pp.
Apeiron, 2000

Infinite Energy previously published an extensive review of Halton Arp's *Seeing Red* (*IE* #31), but since this is one of the most important anti-Big Bang books ever, here is a summary from Mallove's 2000 review: "A gem. . .deserves to be read carefully and pondered by all who seek the truth about the fabric of the heavens. What we see of the universe may continue to evolve in most surprising ways. Matter, and thus energy, may continue to be created in galactic cores (*ex-nihilo*?), and who knows where else. The data that heralds this awareness has been lovingly compiled and offered to a wide audience by a very heroic author with whom we must feel kinship." [Available from *Infinite Energy*—www.infinite-energy.com]

Now, for another, more authoritative voice in support of this book. Here is the first section of a review of *Seeing Red* by astronomer Dr. Tom Van Flandern (from his website http://metaresearch.org):

DON'T READ THIS BOOK. For if you should decide after reading this review to disregard this advice, you will need to prepare to have your universe turned upside-down. Should you then make your way through this small print, 306-page tour de force, you will very likely come away doubting what you thought you knew of the large-scale structure of the universe. The cosmological interpretation of redshift for quasars and active galaxy nuclei has been challenged often before, although never so successfully. But one seldom sees serious suggestions that even the redshift-distance relation for ordinary galaxies may be wrong, as you will see here. And as if the implied revolution in cosmology were not enough, your view of the professionalism of scientists and academics in general, and of astronomers in particular, will be another casualty of your reading.

One can consume this book to different degrees. For example, a short summary of the evidence and implications appears on pp. 239-241. If the writing proves too technical in places, even with the aid of the extensive glossary, one can get the essence of the evidence by just scanning the plates (eight pages in color), figures, and captions that appear on almost every page. For example, it's not difficult to look at the picture of the X-ray filaments in Markarian 205, also featured on the book cover, and to grasp the deep implications of that image. For if a low-redshift Seyfert galaxy is physically connected to and interacting with two high-redshift quasars, one on either side, then redshift can be neither a distance nor a velocity indicator. And that single picture then disproves the Big Bang and most of mainstream cosmology in its present form.

Arp knows the extragalactic sky perhaps better than any other living astronomer. He builds his case against the customary interpretation of redshift methodically. The earliest hints of problems with redshift came in 1911 with the discovery that the bright, blue stars in our own Milky Way galaxy have systematically higher redshifts than the rest of the stars by about 10 km/s. Later observations showed that the O-stars in clusters within our galaxy are redshifted with respect to the B-stars by another 10 km/s or so—something called the "K-effect" and still disputed because it has no accepted theoretical explanation. However, doubts about the validity of the data were undercut and the K-effect confirmed by more recent measures of the redshifts of supergiant stars in the two Magellanic Clouds, nearby companion galaxies of the Milky Way. These too are redshifted by about 30 km/s with respect to other stars in those small galaxies. Yet no one suspects that all supergiant stars in our galaxy or in our immediate neighborhood are fleeing away symmetrically from our own location well out toward one edge of the Milky Way.

Companion galaxies in general seem to have net redshifts that exceed that of their parents. All eleven companion galaxies in the Local Group have redshifts with respect to their parent, the Andromeda galaxy in the center of the group. Likewise, all eleven companion galaxies of the neighboring M81 group have redshifts relative to M81. Yet, if these companions were orbiting their parent galaxy, roughly 50% of them ought to have been blue-shifted. Although the evidence for companion redshifts is less definitive for more distant galaxy groups, it is still statistically significant. Excess redshifts over blueshifts for companion galaxies relative to their parents is apparently a verifiable feature of the local universe. And that means the redshift must have some cause other than velocity.

We begin to get some clues about what may be happening when Arp reminds us of basic facts about radio galaxies. These were discovered long ago to have giant, usually double, radio lobes to either side, presumably the result of explosions and ejections of material from the parent galaxy. Higher resolution radio telescopes have found filaments connecting these lobes to the central galaxy. And the ejected radio pairs are now known to correspond closely with X-ray pairs across the same galaxy.

That brings us to the keys to unlocking the whole puz-

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zle—the quasars—because quasars also often correspond with X-ray sources. High and low redshift quasars are associated far more often than reasonable chance allows. These sometimes display interactions and connections and often form pairs across low-redshift objects, which unrelated objects would not do.

Working entirely from the observational data, Arp shows us that ejections from active galactic nuclei at speeds up to 10% of the speed of light lead to escape. But ejections at slower speeds may not, especially since all ejections apparently decelerate on the way out. Slower objects end up captured at about 400 kpc from their parent galaxy. But both captured and escaped quasars end up with quite small peculiar velocities. Moreover, the closest and therefore most recent ejections have the highest relative redshifts, and the lowest intrinsic luminosities. This leads Arp to suggest that the redshift of matter is an inverse function of the age of that matter. As much as one wishes to resist this conclusion, Arp shows case after case that conforms to it, many found well after this hypothesis was in print, each with odds of thousands to one against chance. Moreover, these apparently ejected quasars with redshifts ordered inversely with distance from their parent also tend to line up along the minor axis of the parent galaxy.

The generality of these startling conclusions is shown by repeated examples, such as the Arp/Hazard pair of similar triplet quasars, having discordant redshifts and a Seyfert galaxy between them. Many other good examples were discovered by mainstream astronomers. However, even when looking in depth at single examples, Arp makes a compelling case against coincidence. A survey of all bright quasars showed that these have a concentration around the Virgo cluster at the center of the Local Supercluster, despite having redshifts that should place them far out into the universe in that direction and make them unrelated to one another. The most conspicuous quasar in the sky is 3C273, one member of a pair of quasars almost exactly aligned across the brightest galaxy in the Virgo cluster center. A peculiar hydrogen cloud known to be in the Virgo cluster near the coordinates of 3C273 has a long, narrow shape pointing back toward the quasar, which itself has a jet pointing toward the hydrogen cloud. An X-ray radiation map (see Figure 5-16 in book) also shows connections between the cluster to the quasar. Yet the quasar is supposed to be 54 times farther away than the cluster, according to its redshift. As Arp says, over thirty years ago, the field of astronomy took a gamble against odds of a million to one that this situation was an accident. The newer X-ray and hydrogen cloud evidence have confirmed that this was a bad gamble, although the field is not yet ready to accept its losses and move on.

Because redshift is not a good distance indicator, Arp points out that apparent brightness often is. Quasars near M49 appear relatively random on a sky map until just the brighter ones in a half-magnitude range are plotted. Then magically, there appears a line of quasars emerging from M49 with redshifts decreasing with distance, just as the observation-driven model predicts.

Whenever secondary distance indicators are available, they support this picture. In some cases, Faraday rotation caused by traversing a magnetized plasma can be measured for quasars. So the amount of such rotation ought to be a distance indicator. But it was then discovered that quasars with redshifts of about 2 had only one-third as much Faraday rotation as quasars with redshifts of about 1, when they ought to have had twice as much rotation. By contrast, this is in accord with Arp's model because the redshift $z = 2$ quasars are intrinsically fainter, and therefore generally seen only at closer distances, than those with $z = 1$.

Arp concludes that quasars are initially faint, point-like objects of high redshift that transform into lower-redshift, compact objects surrounded by a fuzz as they evolve. These develop into small, high-surface-brightness galaxies with more material around them. Ultimately these mature into normal, quiescent galaxies.

In this new view of relationships among astrophysical objects, Seyfert galaxies and their close cousins, BL Lac objects, are short-lived evolutionary stages associated with quasar ejection from active galaxy nuclei. In effect, Seyferts are quasar factories. Strong quasar number-counts are associated with a nearly complete sample of bright Seyferts, as compared with non-Seyfert control fields. Some of these associations have laughable explanations in mainstream journal articles. Quasar GC0248+430 is described as a "possibly microlensed quasar behind a tidal arm of a merging galaxy," which just happens to be a Seyfert.

Indeed, quasars look to astronomers like small portions of active (Seyfert-like) galactic nuclei. Their pairing across such nuclei, their alignment with radio emission pairings, the correspondences of X-ray maps, and the data from optical emission lines all strongly support the ejection interpretation. If nature has not already provided enough hints, an apparent magnitude vs. redshift (Hubble) diagram shows that Seyfert galaxies have too much redshift at fainter magnitudes and do not follow the same relationship as normal galaxies. Indeed, the Hubble diagram for Seyferts trends toward that for quasars, which likewise do not show a normal Hubble relationship between brightness and redshift. One wonders how many different ways nature must repeat this message about redshift not corresponding to distance before it sinks in with the astronomers.

Other astrophysical objects are in accord with this message. Water maser emissions are also seen in pairs roughly aligned with quasars. X-ray filaments or jets emerge from Seyfert galaxies and end at quasars, often in pairs of similar redshift on opposite sides of the minor axis of the galaxy between. And high-luminosity spiral galaxies have excess redshifts compared to normal spirals, as judged by the Tully-Fisher method of judging distances from rotation rates (which is independent of redshift).

One might well wonder what galaxy clusters have to say about this, since these are clearly physically associated groupings of galaxies. The supporting evidence they provide is truly extensive. Classically, whole galaxy clusters obey a Hubble diagram relation between redshift and brightness with a dispersion of just a few tenths of a magnitude. But 14 clusters north of Cen A have a much larger dispersion with a maximum range of 4 magnitudes. Such clusters have no relationship of the type claimed for ordinary galaxies, and call into question that the classical Hubble relationship can have the meaning usually attributed to it—that redshift indi-

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cates distance—for anything. We may simply have been fooled by both luminosity and redshift being functions of mass, which would lead to an apparent Hubble relationship despite no true distance dependence.

Some of the cluster examples are certainly head-turners. Abell clusters of galaxies with higher redshifts are distributed right down the spines of both the Virgo cluster and its southern hemisphere twin, the Fornax cluster. A complete sample over a large region of the southern sky showed that the strongest X-ray cluster concentration had the two brightest galaxies (M83 and Cen A) at its center, despite much larger redshift for the X-ray clusters. In general, X-ray clusters appear more commonly with redshifts of about 0.06 than chance allows, which in Arp's interpretation marks them as young and intrinsically redshifted.

Supporting data includes cooling flow measures, which indicate that at least 100 solar masses per year are being lost from these clusters. This implies 100 billion solar masses in a billion years. Where is it going? The obvious possibilities can all be ruled out. BL Lac objects, at redshifts intermediate between quasars and cluster galaxies, are apparently progenitors of clusters of galaxies. Normal galaxies within certain redshift ranges tend to align on the sky in strings, with the lowest redshift galaxy near the center. For example, thirteen of the fourteen brightest northern hemisphere spiral galaxies in uncrowded fields fall on well-marked lines of galaxies that have concentrations of fainter, higher-redshift galaxies. And there are anomalous faint, blue, often active galaxies that fill out clusters in the redshift range between 0.2 and 0.4. These apparently evolve into the higher luminosity, lower redshift objects seen at $0.02 < z < 0.2$. Finally, below redshifts of about 0.02 we find strings of galaxies aligned through the brightest nearby spiral galaxies, presumably representing the last evolutionary stage of protogalaxies before becoming the slightly higher redshift companions of the original ejecting galaxies. We are so accustomed to thinking of this sequence as a time evolution that it takes some effort to re-think the whole picture as a mass-luminosity-redshift evolution at a nearly fixed time.

So the young-appearing objects with the highest redshifts are aligned on either side of eruptive objects, which implies the ejection of protogalaxies and the association of redshift with youth. Increasing distance from parent leads to brighter, lower redshift objects, so this is the direction of evolution with age. At redshifts of about 0.3 and distances of about 400 kpc from the parent, quasars become very bright at optical wavelengths and in X-rays, and evolve into BL Lac-type objects—a short-lived stage because there are few of them. Finally, these evolve into clusters of galaxies, which are seen to appear at comparable distances to the BL Lac objects, implying that clusters may originate from the breakup of BL Lac objects.

There is more. . .

Tight multiple-quasars-image groupings were originally dismissed as observational errors until the gravitational lens theory was invoked. Then many more examples were quickly found. G2237+0305 was essentially a high-redshift quasar in the nucleus of a low-redshift galaxy. Lensing was the only way out for cosmologists. The four quasar images were all within one arc second of the galaxy nucleus. But Hoyle computed the probability of such a lensing event as two in a million. Moreover, instead of being arcs as lensing theory predicted, the quasar images are extended back toward the central galaxy. Real arc images don't look much like the predicted arcs either, but rather like part of an expanded shell. This alternative is in better agreement with the existence of radial arcs, jet arcs, dog-leg arcs, and ejected jets that end in transverse arcs.

The last main observational area deals with the quantization of redshifts. In essence, redshifts do not take on all values with equal ease, as they must if they are caused mainly by the velocities of the observed objects. For example, redshifts near 0.061, 0.3, 0.6, 0.91, 1.41, 1.96, etc. occur more frequently than chance permits. Smaller redshifts too occur at preferred periodic intervals, as Tifft has shown in a study confirmed in an independent sample by Guthrie and Napier. The existence of preferred values for redshifts proves that either we are at the center of a series of expanding shells, or redshift does not indicate velocity. Arp cautions that faint quasars with high redshifts do not continue to show this effect, perhaps because the form of the relationship changes at great distances from us (as faintness would suggest). Also, much of the spread that exists around these preferred redshift values is apparently due to the speed of ejection, which can be up to 0.1°C. The average redshift of a quasar pair generally falls closer to a preferred redshift value than does either individual redshift. BL Lac objects show the same quantization, but to a less pronounced degree, as befits their relationship to quasars. Figure 8-16 (in book) shows a striking set of bands and gaps for galaxy redshifts in the X-ray cluster Abell 85 that illustrates the redshift quantization effect at a glance.

Arp's strength is observational extragalactic astronomy. With theory he is less proficient, but has enlisted the aid of Narlikar, Hoyle, and others. The concept of mass increasing with age has no adjustable parameters (the characteristic age being given by the measured age of our own galaxy), yet allows prediction of intrinsic redshifts for objects from K-effect stars to quasars, with results better than an order of magnitude. The Big Bang with many adjustable parameters cannot do as well. Redshift, then, indicates youth. And the slope of the Hubble diagram comes directly from our own galaxy's age. Since luminosity evolves with mass squared, the apparent brightness-redshift relationship is coincidental, and not an indicator of distance. I am no doubt biased here by seeing simpler theoretical explanations for Arp's observational constraints than his variable-mass theory can provide. But Arp concedes in places that theories need to evolve with discoveries, something that the Big Bang stopped doing at a fundamental level a generation ago.

Some of the most entertaining reading in this book is provided by Arp's interactions with his colleagues and with referees and journal editors. Arp spices up these exchanges with a bit of his own philosophy. Despite its pessimism, I wonder how any of us could have evolved a philosophy much more optimistic if we had been in Arp's shoes. Anonymous referees frequently use abusive language such as "ludicrous," or unwarranted generalizations such as "bizarre conclusions based on an extreme bias of the authors wishing to find non-cosmological redshifts." It was not infrequent to find refer-

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ees suggesting that the implications should have been used to prove the observations wrong! A Nobel laureate and former teacher is quoted as saying, "Arp did not get anything right in my course. I should have flunked him but I could not bear to have him repeat the course with me."

We see in the anecdotes frequent occurrences of "sniping," unbacked claims that something is true or false for some reason that is not presented to the author for rebuttal. One example: "Oh those claims have been completely disproved." Arp introduces a few names for some of these battle tactics himself. The "Pleiades maneuver" is one such: Measure so much background that the statistical significance of the obvious foreground (such as the Pleiades cluster) is reduced to insignificance. Reaction to the X-ray map showing the connection of the Virgo cluster and quasar 3C273 produced five arrogant and patronizing referee rejections at two journals, and were viewed even by some colleagues "like a grisly auto accident along the highway."

Sadly, the mainstream is well-adapted for survival. So when Arp succeeds in running the minefield and getting his results published despite the referees, an unwritten understanding is that no discussion or citations will follow so the embarrassing result will soon be forgotten. Arp suggests that a sampling of referee reports, showing "manipulative, sly, insulting, arrogant, and above all angry" referees, ought to be published because it would allow people to evaluate the objectivity of the information they are being allowed to read. ❑❑❑

Forthcoming Book Reviews

Undead Science: Science Studies and the Afterlife of Cold Fusion, by Bart Simon, ISBN 0-8135-3154-3, $60.00, Hardcover, 253 pp., Rutgers University Press, 2002.

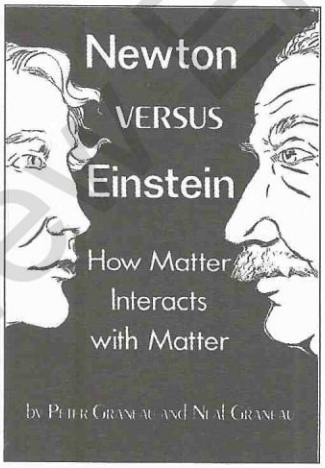
Editor-in-Chief Eugene Mallove will review this book in a forthcoming issue of *Infinite Energy*. He will scrutinize a sociologist of science's perspective on the cold fusion controversy. In particular, he will examine the notion that a large body of compelling and repeatable scientific measurement can be characterized properly as "undead science." Simon's term would seem to presume that the so-called "science" (*i.e.* establishment scientism) that dismissed the evidence is somehow "genuinely live science," and not merely terminally diseased science—in fact, a science potentially near death. This should be great fun: deadly establishment science versus the live organism it most fears—cold fusion!

Albert Einstein: The Incorrigible Plagiarist, by Christopher Jon Bjerknes, ISBN 0-9719629-8-7, $19.95, paperback, 408 pp., XTX Inc., 2002.

Bjerknes' book provides ample references which point to the fact that Albert Einstein was not alone in constructing his theories. The book will be reviewed in Issue 47 by that inimitable critic of relativity theory, our curmudgeonly physics essayist, Thomas E. Phipps. ❑❑❑

Newton Versus Einstein: How Matter Interacts with Matter

Peter Graneau and Neal Graneau



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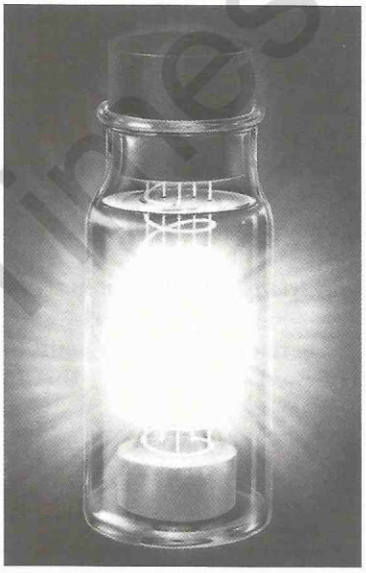
COLD FUSION

Must Be Made Small and Cheap to SUCCEED

Jed Rothwell



Cold fusion or some other radically new source of power may drastically reduce the cost of energy, eliminate nearly all air pollution, and save millions of people from dire poverty.[1] Then again, it may not. To achieve revolutionary results, it will have to meet several criteria:

- ❑ The fuel cost must be very low, or zero.
- ❑ The process must be pollution free, or produce only negligible pollution.
- ❑ Engines and generators must be inexpensive; the materials used to make them must be plentiful and cheap.
- ❑ Engines must be safe and automatic, suitable for houses and automobiles.
- ❑ Power density must be high enough to allow reasonably compact engines.

Several conventional alternative energy sources have not lived up to their potential because they fail to meet some of these criteria. Wind power has zero fuel cost, and it produces no pollution, yet wind electricity ends up costing roughly as much as fossil fuel electricity, because wind turbines are expensive. Turbine costs have fallen a great deal, and in a few years wind may be slightly cheaper than coal or gas, but it will not be far cheaper, because power density is low. Wind turbines take up more space than fossil fuel plants. Dispatchable diesel generators of 1 or 2 MW capacity come in prefabricated steel housing, measuring 4 m tall, 3 m x 12 m long. They have been installed inconspicuously alongside a golf course and on the grounds of an elementary school, where they operate unattended.[2] An equivalent capacity in wind turbines would require six to ten giant towers, with turbines blades as long as airplane wings. This takes much more steel and concrete than the diesel generator. Also, many prime wind locations are far from cities, in places like the North Sea, so they require long high-voltage power lines.

Electricity has three major cost components: fuel, generating equipment, and the distribution grid (power lines and substations). By coincidence, the three components are roughly equal in size: each is about one-third of your electric bill. Thus, in principle, zero cost fuel should cut your electric bill by one-third, but in practice this does not happen. We have not yet discovered a cheap fuel that works well with cheap generators. Uranium is inexpensive but dangerous, so it requires elaborate safety equipment and containment buildings. Wind is free, but it increases the cost of the generators and the grid. Coal is cheap, and the nominal cost of a coal generator is low, but the savings are mainly accrued by passing costs onto the unwary public, killing tens of thousands of people and ruining health and property, according to the Environmental Protection Agency.[3] Coal gasification would eliminate many of these problems, making coal as clean as natural gas, and it would extract more electricity from each ton of coal, but the plants would be more expensive. At present, natural gas has the best balance of fuel cost, low pollution, and large-scale plant cost.

Cold fusion fuel—deuterium—is so cheap that it is virtually free. It is the form of hydrogen in 0.015% of all the water on earth, including freshwater, saltwater, and vapor. Fortunately, cold fusion will probably work with ordinary generators, without containment buildings or pollution abatement equipment. Not only that, it should actually help drive down the cost of the other two components: the generator and grid. The grid will probably not be needed. With cold fusion it will be cheaper and simpler to generate electricity where it is used—at houses, shopping malls, and factories. Cheap fuel should reduce generator costs for three reasons.

First, with most heat engines, you can trade off efficiency for equipment cost.

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Second, energy is fungible. A generator or water heater does only one thing. It has few features, options, bells, and whistles. No one cares how it looks. Cold fusion equipment manufacturers will have only one way to compete and attract customers: optimize for the lowest lifetime cost.

Third, as a general rule, when a major cost component decreases, that creates business opportunities to innovate and reduce other cost components. Cheap microprocessors spurred the development of inexpensive miniature hard disks. Mass-produced automobiles opened the market for improved, cheaper tires. Unfortunately, as noted above, with electricity technical problems prevent this happy synergy, *i.e.* cheap uranium fuel only works with expensive reactors. With cold fusion, the laws of economics should operate normally, and cheap fuel should eventually encourage the development of cheap engines.

Thus, unless some unexpected technical problem arises, cold fusion will eliminate two-thirds of the cost of electricity (the fuel and grid) and it will reduce the final third (equipment).

At present, cold fusion is held back by lack of funding, political opposition, and ignorance.

What Might Prevent This Happy Outcome

At present, cold fusion is held back by lack of funding, political opposition, and ignorance. We do not understand the physics well enough to control the reaction or reproduce it on demand. If these problems are not solved before the present generation of researchers retires, cold fusion may be lost for decades. Let us hope someone overcomes these hurdles by demonstrating the effect hands-on to thousands of people. This will motivate many scientists to join in the research. They will make rapid progress, unless they bump into the limits of present-day knowledge. A few problems—such as superconductivity, a comprehensive cure for cancer, and plasma fusion—have resisted progress despite large infusions of funding and talent. Cold fusion may also languish, but most researchers are optimistic. They have a long wish list of instruments, and dozens of proposed experiments they would love to assign to graduate students. They think they know how to make rapid progress.

We have dwelled on the present unhappy situation in previous articles. Let us assume the scientific and political challenges will be met, and try to imagine what may go wrong after that. Skeptics and worrywarts have listed several potential roadblocks. I think most can be dismissed. They fall in three categories:

1. A shortage of palladium. This might limit cold fusion to use in large, centralized power generators. It would cut electric power costs by one-third, and make electric cars more attractive, but it would not have as much impact on other energy applications. A palladium shortage would also stymie alternative energy devices such as fuel cells. This is discussed in detail below.

2. Insurmountable safety problems. Conceivably, cold fusion cells might explode or generate dangerous radiation on rare occasions, and nothing could be done to prevent it. Most cold fusion physicists believe this is highly unlikely. Cold fusion is not a chain reaction (like fission) although it does increase by self-heating (like fire). The reaction seems to intensify gradually, and it can only occur on or inside an intact lattice. Probably, if cold fusion heat builds up uncontrollably, the lattice will melt, instantly quenching the reaction before an explosion occurs.

3. Problems that do not matter, such as low power density and the high cost of heavy water. Results obtained already sweep aside these issues. Let us look at a few examples.

Problems We Do Not Have to Worry About

Skeptics have looked at today's experiments and claimed that cold fusion will never be practical because it produces a tiny input to output ratio, it only works below boiling, and it takes a long time to turn on. Most experiments do have these limitations, but not all. A few have produced large ratios, or infinitely high ratios, with no input power. Most experiments have low ratios and operate at low temperatures because the cells are not pressurized. Pressurized and reflux boiling cells are inconvenient, since you cannot see inside them. An engine could easily be pressurized. Most experiments are deliberately kept close to room temperature to improve the accuracy of calorimetry. Some cold fusion reactions with bulk palladium cathodes take weeks to turn on. Others, with microscopic particles of metal, thin film, or co-deposition have shorter incubation periods, sometimes a day, or a half hour. Even a half hour would be too long to wait for an automobile engine to start, but this is not a real problem. It seems unlikely anyone would turn off a cold fusion engine, except during maintenance. Presumably, it would be left running constantly in standby mode, to power the control electronics and prevent freezing in winter. This would use only milligrams of fuel over the life of the reactor.

One or two experiments have produced splendid input to output ratios. We do not need to worry about all the others. One or two tests prove high ratios are possible, which means high ratios will be normal in commercial products. Commercial products always work better than early prototypes. Electric lights sold in 1881 were superior to the most promising bulbs in Edison's lab two years earlier. Transistors in radios sold in 1956 were more reliable than the prototypes on the workbenches at Bell Labs in 1952. The same goes for power density. In most experiments it is far too low for a practical heat engine, but a few experiments have produced so much concentrated heat with moderate insulation, the metal cathodes and ceramic proton conductors melted.[4] This proves high heat is possible, and we can assume researchers will learn how to produce it on demand.

The least important limitation is the cost of heavy water. Skeptics who should have known better have said that heavy water costs $400 to $1,000 per kilogram and a cold fusion motor will require several kilograms, making it prohibitively expensive. They are partly right and completely wrong. A small amount of highly pure heavy water does cost $1,000/kg retail, but it is cheaper in bulk, and the price will fall drastically in the future.

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Cold Fusion Motors and Heavy Water Economics

Let us assume cold fusion will work, and have a closer look at what a first generation automobile engine might look like, and how it would compare to a gasoline engine. These predictions are based on conventional plasma fusion reaction energetics and heat engines. They have little to do with the unsolved mysteries of cold fusion. Most would apply to other anomalous new sources of heat.

First generation cold fusion automobile engines will probably be small steam turbines. Later, solid-state thermoelectric engines may become common. Compared to a combustion engine, the cold fusion reaction temperature will be moderate. It will be held close to the highest desired superheated steam temperature, 300°C, about the same as fission reactor pressurized water. A coal flame is much hotter than steam. This "impedance mismatch" is inefficient, and the high temperatures cause wear and tear.

I predict the reactor core will be an array of miniature cells. An array of 100 x 100 cells, each producing 1 watt would probably be safer than one large cell with gas loaded particles producing 10,000 watts.

Cold fusion appears to have performance characteristics and limitations that mean it will work best in a hybrid electric automobile. It seems to ramp up slowly, and once it reaches a certain level of heat production, it tends to remain at that level. In other words, it seems to have "sweet spots"—temperatures and pressures where it works well. Perhaps these qualities are only artifacts of today's experiments, but let us assume they are inherent. Gasoline engines also have a sweet spot. This is why the gasoline engine in a hybrid car runs at a fixed speed, charging the electric batteries that drive the car. Electric motors work well over a broader range of speeds. In a hybrid cold fusion car, the turbine will generate electricity that powers the motor, or is stored in the battery when the car decelerates or idles.[5] The electric motor will also capture kinetic energy when the car slows down.

A hybrid cold fusion engine should cost about as much as a gasoline hybrid. When the technology matures it will be only a little more expensive than today's ordinary gasoline engine. It does not need unusually high precision manufacturing or exotic materials, except perhaps palladium. It will not require expensive pollution control equipment. Cold fusion motors will be sealed against the elements, which will make them cleaner to operate, and reduce wear and tear and maintenance costs.

Suppose a cold fusion motor in standby mode took twenty minutes to reach peak output. In that case, the car would require more batteries than a gasoline hybrid does, to buffer energy while the cold fusion motor ramps up. People living in extreme terrain such as the Alps would require even more batteries. When the car is parked, the cold fusion motor would continue running at full power for a while, recharging the batteries. After a car is left parked for hours, the cold fusion motor would be at its lowest standby power level, but the batteries would be at full charge.

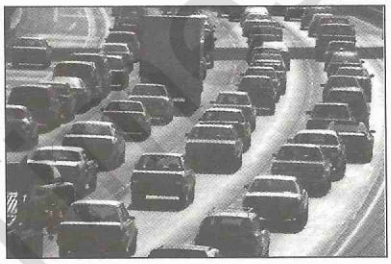
I predict cold fusion motors will use a few kilograms of deuterium gas instead of heavy water, but if they use heavy water they may require roughly 8 kg, mainly to act as heat transfer fluid. This is 7 liters (2 gallons), about as much coolant as a gasoline motor radiator holds. Heat from the gas or heavy water will be transferred to ordinary water, the working fluid in the turbine. People have suggested using the heavy water directly in the turbine, but this would invite contamination.

One of the few well-established facts about the physics of cold fusion is that in one of its forms it converts deuterium to helium-4 and energy at the same rate as plasma fusion does.[6] Let us assume first generation cold fusion heat engines will be roughly as efficient as today's gasoline engines, converting 20% of the heat into vehicle propulsion. A gasoline automobile traveling 30,000 miles in a year uses 1,500 gallons of gasoline, generating 181,000 MJ of raw heat. It converts 36,200 MJ of this heat into vehicle propulsion. (Propulsion ends up heating the surrounding air. All energy finally degrades to waste heat, or entropy.) Cold fusion produces this much raw heat by fusing the deuterium in 1.6 grams of heavy water. Here are some other comparisons:

One kilogram of ordinary water contains 0.015 at% deuterium, or 1 deuterium atom for 6700 hydrogen atoms. (Some sources say 1 in 5400.) When fused it yields roughly 37,000 MJ, about as much as 868 kg of gasoline (310 gallons).

Ordinary water is not suitable for most cold fusion devices. The deuterium has to be extracted and concentrated in 99% pure heavy water. One kilogram of heavy water yields about 115 million MJ of fusion energy, equivalent to 2.7 million kg of gasoline (956,000 gallons).

One mole of heavy water consists of 16 g of oxygen and 4 g of deuterium, so deuterium gas has five times more energy per kilogram than heavy water. A kilogram of D_2 gas has roughly as much energy as 13.4 million kg of gasoline (4.8 million gallons).



The entire world consumes 379 quads of energy per year. (A quad is a quadrillion Btu; 10^{15} Btu = 1.055 Exajoules, or 1.055×10^{18} J.) This would require 3,476 tons of heavy water. The water would convert to 2,780 tons of free oxygen, 691 tons of helium, and 5 tons of the mass would be annihilated, converting into energy, according to Einstein's special relativity formula $E = mc^2$. The same 5 tons of mass is annihilated now, with chemical and solar energy. All sources and forms of energy convert mass to energy. There are 2×10^{13} tons of heavy water on Earth, enough to last six billion years at present energy consumption rates. There is probably a great deal more in the rings of Saturn. The Sun is only expected to last four or five billion years before becoming a white dwarf.

Cold Fusion Will Probably Reduce Raw Energy Consumption

Arthur C. Clarke and others have wondered whether cold fusion (or plasma fusion) might cause a problem by generating too much heat at the surface of the Earth. Actually, cold fusion will probably reduce energy, because it can be used more effectively than fossil fuel. It fits most applications better. It can be used anywhere, including indoors where most machines are located. It should reduce raw heat production in major energy sectors such as electricity, transportation, and lighting. Cold fusion in these sectors may cut raw energy use by ~59 quads, or 16% of total energy consumption. Substantial savings can be expected in other sectors. However, cold fusion will be cheap, so it will encourage peo-

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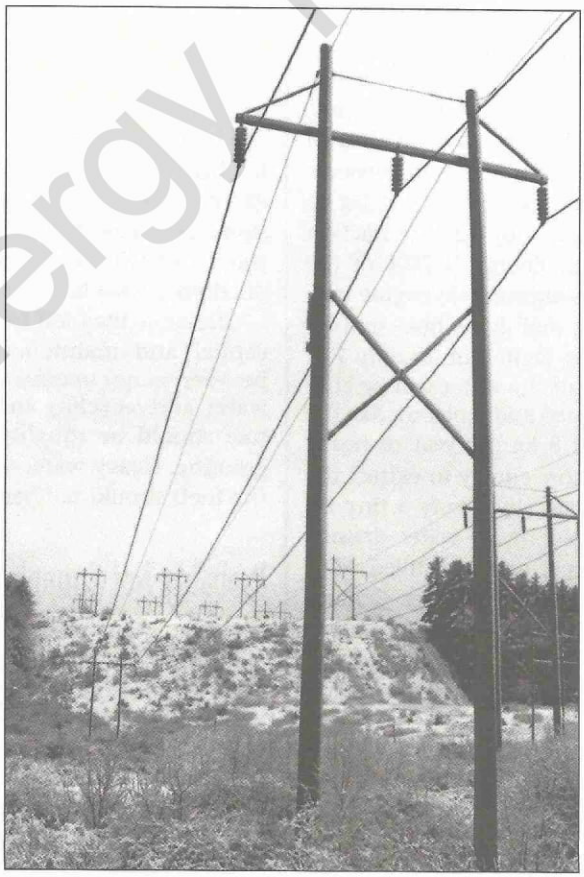
ple to use more energy in new ways, such as massive desalination and water pumping projects to irrigate deserts. In the long run more raw heat may be generated, even though less will be wasted. Let us look at these three sectors.

Electricity: Most cold fusion electric generators will probably be cogenerators, to save space and reduce equipment cost. They will produce electricity and space heating, hot water or thermal air conditioning. At present, worldwide 76 quads are thrown away as electric generator waste heat, and 4 are lost in the grid (also called "T&D"—transmission and distribution losses). Total waste is 80 quads. Let us assume at least half of this would be put to productive use with cogenerators, or eliminated by substituting cold fusion heat for electricity.

Many applications now performed with electricity, such as drying clothes, cooking, and refrigeration, may be done directly with cold fusion heat. Many mechanical applications might be done with cold fusion heat engines. Cold fusion turbines might be used instead of electric motors to drive things like washing machine agitators, blowers, and escalators. This would save some additional energy, but more important, it would reduce equipment costs, and reduce the overall volume of machinery needed. All electric machines are actually two machines: the motor you see and the unseen portion of a generator elsewhere. With cold fusion, you will be next door to the generator. When the electric power company goes out of business, a shopping mall will install a large cold fusion cogenerator outdoors, next to the HVAC (heating, ventilation, and air conditioning) equipment. Assume a mall has ten escalators. It can install ten electric motors, or ten cold fusion steam turbines to drive the machinery directly. Assume the cold fusion motors will be the same size and cost as the electric motors, although they will produce considerably more waste heat. A mall with electric escalators will have to devote 25 kW of its generator capacity to keeping them moving, which will cost ~$6,250.[8] With steam turbines driving the escalator, the mall will get by with a smaller outdoor generator, less equipment overall, lower capital costs, and less space taken up by machinery.

A miniature steam turbine engine driving a washing machine agitator may seem odd to the modern mind, but in the late nineteenth century, small piston steam engines did many tasks we now assume must be done with electricity. Tools powered by compressed air were invented before electricity and are still widely used in garages, factories, and construction. They are reliable and do not spark. Amish people have adopted farm machinery, fans, and kitchen equipment to use compressed air instead of electricity. They make propane-fired refrigerators that use about half as much fossil fuel as electric models, where electricity is generated from coal.[9] Thermal refrigerators and air conditioners have fewer moving parts than compressor models, so they last for a long time.



Transportation: Nearly all transportation depends on gasoline engines, which were invented 120 years ago and are grossly inefficient. As noted above, they are 20% efficient. Most automobile motors invented in the last 95 years—such as electric, hybrid, and fuel cells—are 30% to 50% efficient. Even though inexpensive heavy water fuel will promote the use of low-cost, low-efficiency engine designs, it might actually be difficult to devise a cold fusion engine as bad as a gasoline motor. Assuming cold fusion heat engines work only as well as the worst twentieth century designs, they will be roughly 30% efficient, saving 18 quads.

Lighting: Lighting in first world countries is powered by electricity. We have already counted savings in electricity, above. However, two billion people, one-third of the world's population, have no electricity, so they are forced to squander 1.3 quads in kerosene lamps and candles. These are filthy and dangerous. They produce ~1,000 times less light per joule than electric lamps do. Cold fusion could eliminate this. For that matter, hand-powered wind-up fluorescent lights could have eliminated it in 1960. This would have saved the world's poorest families approximately $52 billion per year, or about as much money as all foreign aid offered by all governments.[10]

Cold fusion glow discharge might be used directly in large outdoor streetlights and search lamps. It would be too hot and dangerous for small lights.

Another major energy use sector, which is often overlooked, is the production and distribution of fossil fuel itself. It includes things like the fuel to run coal mining equipment, oil refineries, and pipeline pumps. An oil refinery consumes 7% of its own output to keeping itself running. Oil accounts for "half the world's seaborne trade" (Shell Oil company). An average new tanker carries about 250,000 tons of oil, and consumes 65 tons a day. Small tankers carry oil from Singapore to Japan then return empty, burning about 1.2% of the fuel they carry. Larger tankers traveling from the Middle East to the U.S. take longer, and they also consume 1 or 2% of the fuel they carry. On land, tanker trucks haul fuel to millions of gas stations, and every gas station consumes electricity for pumps and bright lights at night. Fuel distribution losses are another major source of wasted energy, especially from oil and natural gas pipeline leaks. It is difficult to determine the total cost of this overhead and waste. Estimates

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range from 5% to 10% of all energy (19 to 38 quads). Some experts estimate that the oil industry may consume as much as 20% of its own output in overhead. Coal and natural gas overhead is lower.[11] Cold fusion will eliminate most of this overhead. It will not require pipelines, oil tankers, or gas stations. A fraction of the heavy water output will have to be diverted back into the machines that separate heavy water from ordinary water.

The fuel should be roughly ten thousand times cheaper than gasoline. Heavy water overhead (the energy it takes to make the fuel) should fall below 1%.

There is another major source of energy overhead to consider: the energy required to manufacture motors, generators, wind turbines, and other primary energy generating machines. This is sometimes measured in "energy payback time." For most conventional engines it is quite reasonable. A new gas turbine plant has to be run for about a month before it produces enough energy to build another plant. It keeps working for another 240 months. The energy payback time for a wind farm or nuclear power plant is about three months. Cold fusion motors should be simple, with a short payback time.

Heavy Water Cost

This discussion assumes that cold fusion will require fairly pure heavy water. The most common contamination in heavy water is ordinary water. Heavy water is hygroscopic; it readily absorbs ordinary water when exposed to air. Palladium cold fusion stops producing heat when purity falls below ~99%.[12] A few researchers have reported excess heat from ordinary water with nickel and gold, but these studies have not been widely replicated, and power density was low.

Heavy water is expensive because it takes a great deal of energy to make it. In India, after strenuous efforts to conserve energy at heavy water plants, it now takes 38,000 MJ/kg to extract heavy water. (That is, to separate out the tiny fraction of heavy water from ordinary water.) Energy is 70% of the cost.[13] I predict that a first generation automobile engine may require 8 kg of heavy water, serving mainly as heat transfer fluid. After a year of driving, when the deuterium in only 1 or 2% of water has been fused, the rest of the water will be contaminated, and it will have to be drained and replaced, like the coolant in a conventional engine. If 8 kg per year of heavy water are thrown away, it will take more energy to extract the heavy water than the engine produces, since only a tiny bit will be used. Therefore, contaminated heavy water drained from engines will be recycled, filtered, and redistilled. This takes less energy than producing virgin heavy water. Ontario Hydro uses heavy water to moderate its Candu Fission reactors. It recycles to reduce expenses. Light water and some contamination are removed from the heavy water, which is then returned to the reactor.[14]

Suppose you drive 30,000 miles in a year and pay $1,500 for gasoline. Heavy water costs as much as $1,000 per kg for extremely pure samples, but cold fusion will probably work with 99.9% purity for $385, or even 99.0% purity for $290/kg, retail.[15] The heavy water in a prototype car would cost $2,320 per year, even though the car consumes only $0.43 worth of it as fuel. Thus, unless contamination is much less of a problem than I anticipate, prototype cars and home heaters may not be economical. Although a cold fusion engine will be sealed, and cleaner than a gasoline engine, vibration and high temperatures will limit the life of the seal. Sealed cells that have been run in laboratories for months are usually dirty, with crusted, dry lithium salts and tarnished cathodes. The closest thing to an electrochemical cold fusion cell in common use is an automobile battery. It lasts about five years, and the seal may last longer, but it does not have to withstand high temperatures.

Deuterium gas loaded cells may be more problematic. Even with good seals, the gas will leak gradually. Presumably, cell power will be regulated by changing the cell temperature and gas pressure. Gas will be lost as it is pumped from a holding tank in and out of the cell. Although a gas cell may require only ~1 kg of gas compared to ~8 kg of water, the deuterium concentration and cost will be about the same because the water is mostly oxygen, by weight.

Given the high cost of heavy water today, prototype cold fusion engines will probably not be economical, but the problem will soon be remedied. Since most of the cost of heavy water is for energy, cold fusion will reduce its own cost by powering the extraction machines. Heavy water will still be expensive, at ~$90/kg, so other methods will be used to reduce the cost. A few years after mass production of cold fusion equipment begins, heavy water will be recycled. Engines will consume a larger fraction of the available deuterium. They will have better seals. The techniques for producing virgin heavy water will improve. Little progress in separation technology has been made since the 1950s, because there is little demand for heavy water. Mitsubishi Heavy Industries and the Japan Atomic Power Company are working on next-generation fission reactors moderated with heavy water. They predict "heavy water cost will be decreased drastically with up-to-date [production] methods."

The price may fall to roughly $10/kg, to cover equipment capital and maintenance. When engines run five years between major overhauls, consuming 5 or 10 grams of heavy water, and recycling and extraction technology matures, the fuel should be roughly ten thousand times cheaper than gasoline. Heavy water overhead (the energy it takes to make the fuel) should fall below 1%.

Probably Not Enough Palladium

Years ago Martin Fleischmann said there is only enough palladium in the world to supply about one-fifth of our energy with cold fusion. Based on some rough estimates, I agree. I know nothing about the underlying physics of cold fusion, but it turns out these physics are irrelevant. The limiting factors are in conventional engineering. There may not be enough platinum either, if anodes must be made from it. A shortage of platinum group metals might also prevent the widespread use of fuel cells.

If nickel, titanium, uranium, or gold can produce cold

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fusion at useful power densities, cold fusion may someday supply all the energy we need. If palladium alone works, cold fusion may only be economical in large, centralized electric plants, where the metal can be used with maximum efficiency. These would be cheaper and cleaner than the coal and nuclear plants they replace, but other sources of energy would still be needed.

Most cold fusion researchers agree that other metals will work. Some think other metals are inherently better. Akito Takahashi thinks that cold fusion with ordinary uranium might trigger safe, aneutronic fission in the uranium, which would produce much more heat than the fusion itself.[16] This would be ordinary uranium (U-238), not the rare, radioactive isotope used in nuclear fission plants and bombs (U-235). The metal would gradually be transmuted into other stable, nonradioactive elements, which will probably be worth more than uranium. Uranium is as plentiful as tin in the Earth's surface, so this would be cheaper than heat from heavy water alone, at least until the price of heavy water falls. Unfortunately, Edmund Storms does not think uranium can be used, because of mundane problems with chemistry. Even in a gas loaded system, uranium oxide would form, blocking hydrogen loading. There are some indications nickel can produce low-temperature, low-power density cold fusion. So far no one has seen it produce high-power density. Low temperatures would be fine for space heating, a large fraction of total energy use.

World production of palladium is roughly 8 million ounces per year, or 227 million grams. Palladium is extremely valuable. Intense efforts are made to prospect for it, mine and recycle it. If more could be produced with today's technology, it probably would be. The largest single use for palladium today is in energy production, just as it would be with cold fusion. About 40% of palladium output goes to automotive catalytic converters.[17]

Eight million ounces would never be enough. Suppose all palladium output is devoted to making new generators, all generators run 24 hours a day every day of the year, and when they wear out every gram of palladium is recycled. Suppose power density is so high the palladium is kept on the verge of melting, at several kilowatts per gram. Even at this rate it would take centuries to build enough generators and engines.

With realistic assumptions the prospects are much worse. We cannot devote all palladium to cold fusion. (We would be able to use most of it, since cars would probably be electric or cold fusion powered and we would no longer need catalytic converters.) We cannot run all generators 24 hours a day. A baseline nuclear power plant runs 80% or 90% of the time. It has to be turned off periodically for refueling and maintenance. Other generators are run roughly 60% of the time because there is little demand for electricity at night. The system must have spare capacity to meet peak demand, a few hours a day in the hottest months of the year.

The people working on cold fusion are unaware of the conventional engineering solutions to their problems, and the engineers working on catalytic converters and fuel cells do not realize cold fusion has been confirmed.

We hope to use cold fusion in decentralized power generation, in automobiles and houses, and later individual machines. This makes the peak demand problem much worse. An automobile sits unused most hours of the day. The motor capacity is wasted. A home generator would not be used when people are away at work during the day, or asleep at night. Palladium placed in individual machines, such as flashlights and portable computers, might be used only a few days per year. This would not be a problem with nickel or uranium cathodes.

We will not be able to recycle all the palladium from used cells. In fact, by the time a cell is scrapped much of the palladium may not even be palladium anymore. It may be transmuted into other elements. The recycling problem would be compounded if palladium were used in individual machines. We cannot collect and recycle minute amounts of metal from every broken microwave oven and discarded flashlight. It might be easier with metal in sealed, removable modules that could be separately recycled, like batteries. Recently, tantalum has become expensive and supplies are short, because it is used to make capacitors in cell phones. Most old cell phones are thrown away instead of being recycled. Even if they were turned in for recycling it would be difficult to remove the minute amount of tantalum in each phone.[18]

The round numbers for catalytic converters also indicate there is not enough palladium. Automotive engines consume about one-sixth of the world's energy. Very roughly, if it takes half of our palladium to clean up one-sixth of our fossil fuel pollution, our entire supply would only be enough to generate two-sixths of our energy with cold fusion. At first glance this estimate seems absurd, like comparing apples to oranges. The metal in a catalytic converter does not generate energy. It modifies the composition of the exhaust gas. Yet from an engineering point of view, a catalytic converter resembles a cold fusion cell in important ways. Most of the heat from a gasoline engine passes across the thin film palladium surface in a catalytic converter. In a cold fusion cell, all of the heat originates in a similar thin film or finely divided powder. The stresses, heat damage, melting points, problems adhering metal to substrates, and other challenges are similar. No matter what the underlying physics of cold fusion may be, conventional engineering limitations make it likely that a cold fusion automobile engine would require roughly as much palladium as a catalytic converter does: 10 or 20 grams. The similarities between cold fusion cells and catalytic converters illustrate another important point. Most of the technology we need for cold fusion has already been invented. The people working on cold fusion are unaware of the conventional engineering solutions to their problems, and the engineers working on catalytic converters and fuel cells do not realize cold fusion has been confirmed. Once it becomes generally known that cold fusion is real, many experts will

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rush into the field with off-the-shelf solutions, such as how to clean cathode surfaces so that hydrogen reaches the metal. Rapid progress can be expected, at least at first, until we come up against basic unsolved physics problems.

Thermoelectric Generators and Motors

First generation cold fusion engines are likely to be steam turbines because this is a mature technology. Eventually, most cold fusion devices will be solid-state thermoelectric generators (TEG) instead. These are similar to photovoltaic (PV) chips, except that instead of converting light to electricity, they convert heat to electricity. They have no moving parts, and thus require little maintenance, even less than PV arrays. PV arrays are mounted outside. They must be cleaned off periodically or dust and grime reduce the amount of sunlight that reaches them. A conventional TEG is heated with gas combustion, which is much hotter than cold fusion and leaves deposits and soot. A cold fusion TEG will remain sealed and clean, and will operate at comparatively moderate temperatures.

Most thermoelectric devices available today are expensive, and they are only 5% efficient, making them impractical for many applications. They would be fine for a low-power telephone repeater, but too bulky for most heavy-duty machines. An automobile with a 5% efficient engine would resemble an old-fashioned steam locomotive or steam tractor: it would be all engine, oversized, dangerously hot, and underpowered by modern standards. Five percent conversion would be impractical for use inside household machines. It would make a laptop computer as hot as a toaster!

In 1992, Tom Droege, a cold fusion skeptic from Fermilab, told me that TEG efficiency would not improve much beyond the 5% limit. He quoted an article titled "Thermoelectricity: The Breakthrough That Never Came": "When questioned closely, however, [scientists] usually agree with the man who confessed sadly, 'When you get down to the lower right hand corner of the periodic table and you still haven't found what you are looking for, you have to face the idea that you have run out of things to play with.'" As usual, the skeptics were wrong. By 1998 a prototype three-stage device at Japan's National Aerospace Laboratory (NAL) of the Science and Technology Agency (STA) achieved 17% efficient conversion, at 800°C.[19] Three stages means three types of thermoelectric chips are used in one device, with the waste heat from one going to the next. The first is optimized for high-temperature conversion, the second for medium and the third for low-temperature conversion. Similar techniques were used in earlier heat engines, such as triple expansion marine steam engines (1882). Droege overlooked this technique, and probably many others. Engineers often know about pre-existing textbook solutions that would not occur to a scientist. NASA's Jet Propulsion Laboratory (JPL) thinks that 14% efficiency for a single stage device is possible.[20] In 2001, cold fusion scientists Yan Kucherov (ENECO) and Peter Hagelstein (MIT) claimed they achieved 17% with a revolutionary single stage device, and they say the theoretical limit is 50%.[21]

TEG are made of bismuth, tellurium, lead, silicon, and germanium, which are cheap and plentiful. TEG are expensive because demand is low. Cold fusion will create an unprecedented demand for mass production, rapidly pushing down costs.

Safety and Control

Cold fusion will have to be perfectly safe, because modern society is irrational about safety. Consumers demand extreme precautions for new technologies such as air travel, yet they dismiss the dangers of driving automobiles. We must develop perfect control over cold fusion. We must learn how to ramp it up to hundreds of degrees at will, not once or twice by blind accident as we have done so far, but on demand, automatically, in millions of heat engines, without a single accident or explosion. Presumably, the only way researchers can learn to make foolproof devices is to find out how cold fusion works on the atomic level. It seems unlikely they will learn by trial and error or empirical methods.

We do not have perfect control over conventional energy sources, and they are more dangerous than people realize. Once you ignite a pile of coal, you must let it burn. When wet coal is shoveled into a fire it sometimes explodes. Much else can go wrong with the enormous concentrations of potential energy in volatile fuel. Babcock and Wilcox laconically described an accident at a 500 MW coal fired plant: "The boiler was off line for routine maintenance in February, 1999. Due to an unfortunate sequence of events, the boiler filled up with natural gas and subsequently exploded. The eleven-story structure was reduced to a five-story pile of rubble."[22] Even critically important heat engines fail. Jet aircraft engines sometimes stop working in flight, although the passengers seldom notice it. You can SCRAM a nuclear reactor and stop the fission reaction, but the uranium core remains hot for days—so hot, it will melt catastrophically unless tons of cooling water are pumped through it. When people first built wood and coal fired steam engines, they did not understand the physics of fire or how to engineer a safe boiler. Their ignorance caused many fires and explosions. That was acceptable 250 years ago, but people will demand higher standards for cold fusion. Homeowners, corporations, Congress, and the insurance

Presumably the only way researchers can learn to make foolproof devices is to find out how cold fusion works on the atomic level. It seems unlikely they will learn by trial and error or empirical methods.

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companies will not allow cold fusion generators if they think there is the slightest chance one might explode or irradiate someone, even if cold fusion reactors are demonstrably safer than coal, gas, and fission generators.

Perhaps, if a severe shortage of fossil fuel develops, even if perfect safety cannot be assured, society will allow large centralized cold fusion reactors in locations far from cities, replacing coal and fission generators.

The Disappearing Distribution Grid

The distribution grid and large, centralized generator plants exist for several reasons, none of which apply to cold fusion. Actually, the grid is already obsolescent in some ways, and it is fading in economic and technical value. Cold fusion will accelerate changes already underway. In Japan, decentralized privately owned cogenerators have reduced the demand for centrally generated electricity. Cogenerators were built nearly a century ago at Cornell University, and the network of steam pipes from generator plant still keeps offices and classrooms warm in winter.[23] This is sometimes called "district heating."

Decades ago, a 500 MW generator was more efficient than a small generator, giving it economy of scale. Nowadays, a 1 MW aeroderivative gas generator is just as efficient as a larger gas turbine, and much more efficient than a 500 MW coal-fired generator. Years ago all generator plants, large or small, required many people to operate them. Workers swarmed over coal plants and hydroelectric dams, performing maintenance and keeping track of conditions. Large plants required comparatively fewer people per megawatt of capacity—another economy of scale. Nowadays, many jobs are done automatically by computers, or by remote maintenance. Small, unmanned dispatchable generators are just as reliable as big plants. They resemble jet aircraft engines and railroad diesel engines. Like airplanes and railroad locomotives, they operate safely for weeks between scheduled maintenance. With cold fusion, economies of scale and fuel efficiency will make no measurable difference. Cold fusion generators will be as reliable as any other modern piece of equipment.

The grid was needed with large fossil fuel plants because they were built far from cities, to dilute pollution. Nowadays we prefer to control or eliminate pollution instead. Pollution can be controlled just as effectively in a medium scale gas turbine as it can in a giant turbine. This is why 500 kW cogenerators can now be installed in downtown Tokyo. Cold fusion will not pollute, so this will not be an issue.

The grid is needed with nuclear power plants because they too must be built far from cities. Not because they pollute, but to reduce the potential damage from a nuclear accident. Cold fusion will be perfectly safe or it will not be allowed in the first place, as explained above.

Hydroelectric and wind turbines can only be located in certain geographical areas, usually far from cities, so we need the grid to bring the power where it is needed. Cold fusion can be used anywhere.

If the distribution grid did not already exist, and it was not already paid for, it is unlikely we would build one from scratch. It would be cheaper to construct small local grids, district heating with cogenerators and low capacity interconnections between local grids. This would reduce the need for high-voltage power lines, which are ugly and destructive. Some people suspect they cause health problems. The evidence for this is weak, but there is no question power lines wreak havoc on the environment and wildlife. Millions of trees are cut to clear a major powerline right-of-way, and defoliants (or sheep) are later used to prevent regrowth.

Samuel Florman thinks that small generators may not be reliable. He wrote, "we all resent the electric and phone companies but, when service is interrupted, a competent crew arrives on the scene to set things right. It is easy to say that solar collectors or windmills in our homes will be serviced by our independent neighborhood mechanic, but this is a prospect that must chill the blood of anyone who was ever had to have a car repaired or tried to get a plumber in an emergency."[24] Florman does not live in Atlanta, Georgia, where winter ice storms knock out the power for hours or days at a time. A repairman from Sears comes to fix appliances or replace the water heater almost as promptly as the electric power company shows up, and he is summoned less often. Since cold fusion generators will be critical, HVAC maintenance companies might offer rapid service swap replacements, the way automobile dealerships offer loaner cars. Should first-generation cold fusion generators turn out to be somewhat unreliable, it might be reasonable to install two, each with about half the maximum capacity you require. At our house, the heating contractor recommended we install two small gas furnaces instead of one large one, because only one is needed at night. The equipment is a little more expensive, but it is more economical to operate and on the rare occasions when one heater breaks we do not mind waiting until the repairman shows up. In any case, cold fusion generators will never be repaired by "independent neighborhood mechanics." They will be high-tech devices with no user serviceable parts inside. When one stops heating, a do-it-yourself homeowner will go to Home Depot and buy a sealed replacement heater module.

Waste Heat, Efficiency, and Electricity

I estimate that 110 quads of energy are used to generate electricity. The energy converts into 34 quads of useful electricity, and 76 quads of waste heat, which are thrown away. This is based on a 1985 worldwide estimate of efficiency, updated with 1999 consumption data.[25] This issue is complicated. Some generator types, such as wind and hydropower, are not heat engines so they do not produce waste heat (except from friction). Cogenerators produce waste heat in the engineering sense, but it is not wasted; it is put to good use. Coal and nuclear power plants cannot be used as cogenerators because they are too far from cities and factories where the heat is needed. They are built in distant places to disperse pollution and reduce the danger from a nuclear accident, but we might use the waste heat anyway. We could build things like lumber kilns or desalination plants close to nuclear power plants. Kilns use copious low-temperature heat, which is what you see being thrown away in billowing clouds of condensed steam that drift from the giant cooling towers at power plants. A kiln or desalination plant has few workers, so not many people would be endangered in the unlikely event of a nuclear accident.

Modern gas turbines are 35% to 45% efficient, but most electricity comes from older, coal fired plants, so overall worldwide efficiency is about 33%. After conversion and

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transmission losses, experts agree that only 31% of the original energy reaches the end-user. Unfortunately, a great deal is then wasted by inefficient motors, incandescent lights instead of fluorescent ones, and resistance electric heating instead of natural gas or heat pumps. The experts do not agree how much electricity is wasted in the last stage. In a 1990 paper co-authored by the Electric Power Research Institute (EPRI) and the Rocky Mountain Institute, EPRI said 28% of electricity was wasted, and the Rocky Mountain Institute said 75%. Numbers like this usually vary a great deal from one source to another. The experts disagree for good reasons. In this case, "waste" is defined as an expense that can be reduced in a cost-effective manner. The Rocky Mountain Institute thinks solar water heating is cheaper than electric water heating, so it says electricity used to heat water is wasted. EPRI thinks electric heating is cheaper, so it says this electricity is put to good use. EPRI and the Rocky Mountain Institute also disagree about the economics and potential improvements in lighting, heat pumps, appliances, and so on. Small differences in individual estimates, assumptions, and projections for each of these devices add up to a large difference in overall projected savings.[26] You wonder how power companies ever manage to predict customer demand.

I estimate 40 quads of waste from electricity can be eliminated with cold fusion, with cogeneration and direct use of cold fusion heat substituting for electricity. This estimate is conservative. Actual savings are likely to be much higher, because cold fusion heating and refrigeration will save so much more energy.

In commercial buildings ~35% of electricity is used for HVAC. In U.S. houses ~62% of electricity is used for refrigeration, water heating, and air conditioning.[27] In a cold fusion powered world, a refrigerator or air conditioner might be run by electricity generated with cold fusion, but it would be much simpler and cheaper to run it directly with cold fusion heat. This would take less equipment, and thermal refrigerators last longer than electric ones. They are more expensive today mainly because there is not much demand for them. Assuming about half of electricity is used for heating and refrigeration, and this is all replaced with thermally driven machinery, total electricity generation will be reduced to 55 quads of raw heat, converting to 17 quads of useful electricity and 38 quads of waste heat. Much of that waste heat will, in turn, be put to use in cogeneration applications. Cogenerators are attractive today because they save energy. This will not be an issue with cold fusion. The energy they save will only be worth a few pennies per year. However, cogenerators will still be popular because they will reduce the need for machinery and save space. Since a cold fusion generator will be installed next to every house and building anyway, it will be cheaper to run the space heating and air conditioning from the waste heat, rather than adding a separate set of heaters. A refrigerator will probably need its own dedicated cold fusion heat source.

In this scenario, instead of saving 40 quads as I estimated above, total savings from electricity would be approximately 74 quads of raw heat, a 67% reduction. Savings in other applications such as transportation may eventually rival this, if, for example, Kucherov and Hagelstein successfully develop a 50% efficient TEG. This illustrates the benefits of flexible, scalable energy that can be used anywhere, not just in huge central generating plants.

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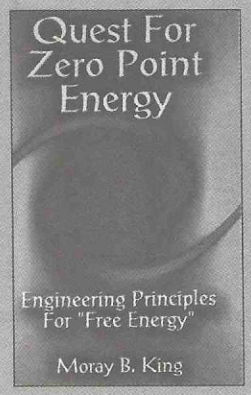

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What Is Missing In Les Case's Catalytic Fusion

Wladimir Guglinski*

Abstract

Dr. Les Case's catalytic fusion has been repeated by Dr. Michael McKubre, who has commented:[1] "One of the difficulties in the cold fusion field is the apparent lack of replicability of experiments: many people performing the same experiment get apparently different results; different experiments performed in the same laboratory give apparently different results. . .What this is telling us is that there are some important parameters of our experiments that are not under control. . .We just don't know what the process is that we are studying, so we don't know what parameters we need to control in order to yield a consistent result."

Of course, there are some important parameters that are not under control, because we do not have a theory from which we can understand the reaction d+d → He-4 in the Case process. Without a theory, we are unable to discover these unknown parameters.

I proposed a new model of the neutron[2] and a new fundamental concept[3] that perhaps can help us to understand how the reaction d+d → He-4 is promoted in Case's catalytic fusion.

Herein I analyze the Case process by considering such a new concept.

The New Concept Proposed by the Author

In my paper[3] I show that a neutron model n = p+e requires a new fundamental concept,[4,5] and have proposed it with the following argument in my paper.

If we consider the ether constituted by electromagnetic particles and by gravitons, through such a consideration it means that Planck's constant h is due to interactions by electromagnetic particles of the ether, while the constant h_G is due to interactions by gravitons.

Note that we are proposing here the constant h_G through the same way that Planck proposed the constant h. Indeed, Planck was constrained to adopt the hypothesis of the constant h, because that was the unique solution able to solve the paradox of the ultraviolet catastrophe of a black body. By the same way, today we have two experiments, made by Borghi and by Conte, and these two experiments show that the neutron structure is n = p+e. And the unique way to explain this structure, obtained by the experiments, is through the adoption of the following hypothesis:

For a potential well with radius a≤1fm, Heisenberg's uncertainty principle is

$$\Delta x.\Delta p \sim h_G,$$

where $h_G \sim 1.3 \times 10^{-37}$ J-s is the *gravitational quantum* of energy.

Before submitting my paper[3] to the *International Journal of Theoretical Physics*, I submitted it to other scientific journals. The Editor-in-Chief of the *European Journal of Physics* replied as follows :

> I appreciate your appeal to the history of physics. However, the problem of the uncertainty relation and gravitation is deeper than you seem to know. Firstly, there is no uncertainty relation in special relativity as you could learn from the introduction into quantum mechanics of Landau and Lifshiz. Secondly, the problem to unify quantum mechanics and gravitation, *i.e.* general relativity, represents the most difficult and deep problem of today's physics. A good introduction can be found in Weinberg's book on quantum field and theory. I regret that your historical allusions do not apply to your manuscript and cannot come back on my decision to reject your paper.
>
> Sincerely yours,
> Prof Th. Walcher
> Editor-in-Chief of *EPJA*

So, I replied to the editor as follows :

> Weinberg, Hawking, Penrose, Gell-Mann, and others are trying new theoretical attempts by keeping the fundamental principles of QM. Such an attempt makes no sense, because they are rejecting the following fundamental fact: *the structure of the neutron n = p+e requires new foundations.*
>
> They cannot try any new attempt before answering why the structure n = p+e is possible (as the experiments are proving), although it is *impossible* according to the laws of quantum mechanics.
>
> It is not by neglecting the experiments (like the positivists physicists of today's physics are doing) that we can find the solution able to eliminate the incompatibility between relativity and QM.
>
> When Michelson carried out his experiment at the end of the nineteenth century, the majority of physicists neglected his experiment. Only scientists like Einstein, Lorentz, Poincare, and Fitzgerald understood that to neglect an experiment does not fit the scientific method. That's why they started to look for a theoretical solution for the paradox, since the results of the experiment did not fit the prevailing foundations of that time.
>
> Today the experiments made by Conte-Pieralice

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and Don Borghi also require a theoretical solution. Unfortunately the physicists are neglecting their experiments. It is not the procedure we expect from scientists.

A referee of the *Chinese Journal of Physics* exhibited an objection similar of that from Dr. Th. Walcher, saying that he finds it hard to accept a new Planck's constant. That's why (taking in consideration the objection of the referee of *CJP*), before submitting the paper again to another journal, I decided to put one additional item in the paper, where I incorporated the objection of the referee of the Chinese journal, as follows:

Conclusions:

The first reaction of a referee against the proposals of the present paper probably would be to claim the following: "It is hard for me to believe those difficulties raised in this manuscript will have escaped the scrutiny of all those prominent particle theorists. For instance, the author proposes a new Planck constant for the uncertainty principle in the femtometer scale. Had this been true, the string theorists should have encountered the difficulty a long time ago and would even have proposed their own third different Planck constant."

However, up to now theorists have neglected Borghi's experiment, and this is just the reason why they never tried such a new theoretical alternative.

Indeed, the proposal of a new Planck's constant, proposed herein, is required by the results of two new experiments, made by Conte-Pieralice and Borghi. Even if the present new proposal is not a definitive solution, nevertheless any other different solution must be proposed by considering the results of Conte-Pieralice-Borghi experiments. By neglecting their experiments is impossible to find a satisfactory solution.

It is also important to consider that the "spin-fusion" hypothesis is able to open new theoretical perspectives for the Particle Physics, through the establishment of a new Standard Model, as shown in the author's paper "New Model of Neutron-First Part,"[1] published by *JNE*, where it is shown that the total spin is not conserved in beta-decay. Since the leptons are tied to the quarks through the spin-fusion, as proposed by the author, such a new proposal represents a new fundamental concept to be applied in the nuclear theory and in particle physics.

So, let us analyze Case's catalytic fusion through the consideration of the "gravitational quantum" of energy.

Unknown Parameters

First of all, let us consider McKubre's words, *"different experiments performed in the same laboratory give apparently different results."*

This seems to imply that in two different days, the conditions in the laboratory have changed. But since every parameter seems to be under control, perhaps we have to consider that the Sun's magnetic field changes when there are magnetic storms on the surface of the star. For instance, suppose that the Earth's magnetic field is able to help the alignment of the deuterons, increasing the speed of the reaction d+d → He-4. In this case a magnetic storm in the Sun's surface could eliminate such a help by the Earth's magnetic field, and the reaction d+d → He-4 would not occur.

Or suppose that in Case's process there is an interference by a parameter like the Sun's magnetic field. We can try to eliminate the influence of the Sun's field by creating a new type of Case process, in which the Sun's influence will be minimal. Let us see how to get it.

Case's Catalytic Fusion

Dr. Les Case did not use an oscillator in his process. Then let us try to understand, by considering the new concept of a "gravitational quantum" of energy, what happens in the traditional Case experiment.

The proton-neutron of the deuterons D_2 are subjected to vibratory motions, as happens to the whole nuclei (a similar effect of the Brownian motion for the molecules).

The oscillatory motion of the proton-neutron in the D_2 is able to induce a vibration of the gravitons (gravitational quantum of energy). Then a resonance between the oscillation of the proton-neutron particles and the oscillation of the gravitons occurs. However, the amplitude of the oscillation of the proton-neutron particles depends on the temperature and pressure in the vessel of Case's catalytic fusion. If we change the temperature-pressure condition, such a condition is able to eliminate the resonance between the motion of the gravitons and the proton-neutron particles. Since the resonance gravitons-hydrogen is fundamental for the reaction d+d → He-4, we may understand that it is very hard to find the correct point of resonance.

Borghi's Experiment

Don Borghi applied a high-frequency ionizing e.m. field in his experiment. In his paper[4] he says:

> This requires that the stronger, and quicker, Coulombic interaction may be avoided by means of a high-frequency ionizing e.m. field. This field succeeds in maintaining a "cold" plasma, *i.e.* a considerable number of protons mixed and colliding with an equal number of free electrons, for a time much larger than 10^{-8} sec. This limit is suggested by the known average recombination time of the ionized hydrogen atom. The high frequency has been taken to be of the order 10^{10} sec^{-1}.

However, I believe that such a high frequency actually is responsible for two reasons, one considered by Borghi, but the other unknown by him, as follows:

1) The high-frequency e.m. field succeeds in maintaining a "cold" plasma, as considered by Borghi.

2) The high-frequency e.m. field succeeds in achieving a resonance of gravitons-proton-electron.

Such a conclusion seems to be obvious, for the following reason: Since the high-frequency e.m. field succeeds in maintaining the cold plasma (the protons and electrons in free state, without to perform the neutron), then such a high-frequency would have to keep the protons and electrons like a plasma for so long, and the neutron would never be obtained in Borghi's experiment. So, how does one

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explain that neutrons have been obtained? I believe that it can be explained through the hypothesis that the high-frequency e.m. field promotes the resonance of gravitons-proton-electron, and such a resonance succeeds in fusing a proton and an electron into a neutron.

Note: The interaction due to gravitons with high-frequency of oscillation is a dynamic sort of gravitational interaction, different than the well-known stationary gravitational interaction. Dynamic gravity has been obtained, for instance, in high-energy experiments, from which we know that the magnitude of the strong nuclear force depends on the collision speed of the particles (the faster the speed of the particles, stronger is the interaction).

New Version For Case's Catalytic Fusion

Perhaps the speed of the reaction d+d → He-4 in the Case process can be increased by the application of a high-frequency e.m. field.

From Einstein's equation $E = h.\nu$, we may know the relation between the gravitational constant h_G and the frequency ν. For the condition of resonance, E must be proportional to 10^{-n}, where n is an integer. So, suppose that n = 27 and since $h_G = 10^{-37}$, then $\nu = 10^{10}$/sec, which is the frequency used by Borghi.

With the introduction of a high-frequency e.m. field in Case's experiment, we can hope to obtain two results:

1) The influence of the Sun's magnetic field will be eliminated, and the apparent lack of replicability will be eliminated.

2) The speed of the reaction d+d → He-4 will be increased.

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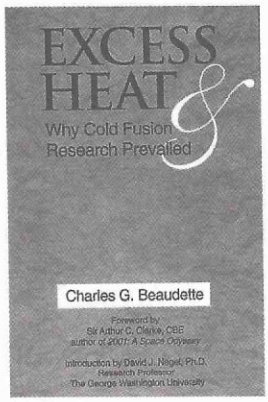

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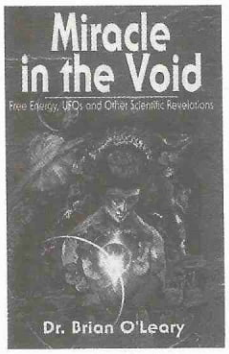

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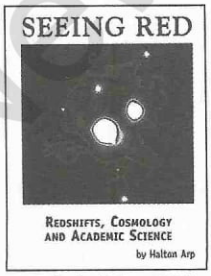

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Comparison Between Two Theoretical Models for Deuteron-Plasmon Interaction with Enhanced Tunneling Effect

Fulvio Frisone*

Abstract

This paper presents a theoretical analysis of the possible effects that different concentrations of impurities contained in the lattice can have on the phenomenon of fusion catalyzed by deuterons. The numerical calculation, performed for Ni, Pd, and Pt at fixed lattice temperature, as a function of the degree of impurity at 0.28% and 0.72%, shows that the probability of penetrating the Coulomb barrier increases with increasing impurity. This result can be interpreted considering the trend of the potential describing the effective interaction between deuterons within the metal; this in effect shows that the coupling between plasmons and deuterons, in the presence of impurities, is not only able to reduce the thickness but also lower the height of the Coulomb barrier K in various types of deuterium-loaded lattice. Further, we consider the influence of the temperature on the phenomenon of deuteron fusion within metal lattices with CFC or HC structure, hypothesizing that a kind of chain reaction, catalyzed by microcracks—which form in the structure as a result of variations in the thermodynamic conditions or for other reasons—can promote the process. From the numerical simulation performed for different metals (Pd, Pt, and Ti), varying the temperature and the total energy, it is possible to conclude that the probability of interaction is in effect notably enhanced by increasing these parameters.

I. Introduction

This paper will refer to the results obtained from a study carried out during the last two years, during which a comparison was made between the trends of the probability of fusion in three-dimensional lattices, obtained according to two models. In the first, the lattice temperature is constant and the deuteron energy is varied; in the second, both parameters are varied. From a quantitative viewpoint, the higher probability of fusion was found within a lattice with cubic symmetry and ≥ 8 "d" band electrons. Further, useful indications were obtained regarding the possibility of lowering the height of the Coulomb barrier by varying the energy of the deuterons.

In a previous paper[1] it was found that the phenomenon of fusion between deuterium nuclei in the crystalline lattice of a metal is conditioned by the structural characteristics, the dynamic conditions of the system, and also by the concentration of impurities present in the metal under examination.

In fact, studying the curves of the interaction potential between deuterons (including the deuteron-plasmon contribution) in the case of three typical metals (Pd, Pt, and Ti), in a three-dimensional model, it was found that the height of the Coulomb barrier decreases on varying the total energy and the concentration of impurities present in the metal itself.

In this model, at fixed lattice temperature, the contribution from deuteron pulsation does not evidence a thermodynamic-type effect. In fact, the equilibrium lattice temperature is much lower than that corresponding to the energy of the deuterons; on the other hand, if the deuteron energy is increased, the height of the Coulomb barrier decreases, thereby determining a large increase in the probability of fusion.

In the present paper, we intend to study any possible influence that variations in temperature may have on the phenomenon, since this could favor the fusion of deuterium nuclei as a result of deformations or microcracks produced in the lattice. These could have the effect of concentrating in their vicinity a relevant fraction of the deuterons present in the metal.

The phenomenon hypothesized should possess characteristics analogous to the formation of Cottrell atmosphere in metals, well-known in solid state physics, which essentially consists of a redistribution of the impurities present in a metal around a dislocation of the ions making up the lattice.

In these cases, the interaction between the impurities present and the dislocations can significantly modify the electric properties of the material; further, particular reactions can occur, incorporating the impurities in the nucleus of the dislocations as a result of the different arrangement of the atoms compared to that of the non-perturbed lattice. This type of process has been extensively discussed in the literature for high-temperature crystalline semiconductors and metals. In the latter, for example, it has been demonstrated that the concentration of interstitial impurities around a linear dislocation with point component depends on the temperature according to a law of the type:

$$c = c_0 \exp\left[\frac{\beta}{b\,k\,T}\right] \tag{1}$$

where c_0 is the concentration of impurities in the zones with zero internal pressure, $b^3 \simeq v_i$ the volume of the ions making

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up the lattice, while β is proportional to the difference $v_d - v_i$ between the volume of impurity atoms and that of the lattice ions.

Our conjecture is that similar phenomena may also occur between the deuterium atoms penetrating into the lattice and the microcracks caused by variations in temperature, in metals such as Pd, Pt, and Ti. In this case, parameter β of Equation (1) would be negative, producing an increase in the concentration of deuterons in the vicinity of the microcrack, which would then catalyze the phenomenon of fusion.

If this actually happens, it is not difficult to hypothesize that the energy produced by micro-explosions within the cracks present could favor the creation of new cracks which, in turn, would capture other deuterons by the same mechanism, thus producing a kind of chain reaction. In this regard, the formation of microcracks provoked by the energy released in Pd electrodes during long periods of electrolysis with deuterium has already been observed experimentally,[1,2] but until now has been considered only a consequence of nuclear fusion. Our hypothesis is that such phenomena could instead favor the process, enhancing the probability of the fusion of deuterons absorbed by the metal lattice of the target.

This paper extends the mathematical approach used in Reference 1 to the three-dimensional case, and demonstrates that variations in lattice temperature allow the further "lowering" of the height of the potential barrier compared to that produced by impurities alone. This could be a direct consequence of new phenomena linked to the formation of microcracks.

The paper is articulated as follows: Section II briefly reassumes the results of previous research on the fusion of deuterium nuclei according to a three-dimensional model; Section III extends the analysis to a three-dimensional model with cubic symmetry, where effects due to variations in temperature, total energy, and thermodynamic conditions of the system are taken into account; Section IV presents the conclusions and final comments.

II. Three-dimensional Model Temperature ≠ Constant and Variable Energy

Our aim is to demonstrate the possibility that the presence of impurities results in an enhancement in the probability of fusion in lattices at constant temperature and variable energy. For simplicity, the effects of pressure will be ignored.

This section presents a summarized study of the effect that different concentrations of impurities contained in the lattice can have on the phenomenon of deuteron fusion. Graphical and numerical representation for Pd, Pt, and Ni at fixed lattice temperature in function of the concentration of impurity at 0.28% and 0.72% shows that the probability of penetrating the Coulomb barrier increases with the degree of impurity.

This result can be interpreted by considering the trend of the potential, which describes the effective interaction between deuterons within the metal. In effect it shows that in the presence of impurities, coupling between plasmons and deuterons is able not only to decrease the thickness but also lower the height of the Coulomb barrier K in various types of deuterium-loaded lattices (Figure 3).[3]

In a three-dimensional model, the probability of fusion between free deuterium nuclei outside the crystalline lattice of the metal is equal to the probability of penetrating a potential Coulomb barrier $V(r)$, given by:

$$\left|P\right|^2_{free} = \exp\left(-2\int_0^{\alpha} K(r)_{free}\, dr\right) \qquad (2)$$

where α is about 0.56 Å, $K(r)_{free}$ is given by:

$$K(r)_{free} = \sqrt{2\mu\left[E - V(r)\right]/\hbar^2} \qquad (3)$$

E is the total initial energy in eV, substantially thermal in nature; μ is the reduced mass of the deuteron, and $\hbar$ is Planck's constant.

The region of greatest interest is that where $E \leq V(r)$. Equations (2) and (3) refer to the process of "free" fusion, *i.e.* outside the lattice.

An important effect of the metal lattice on the reaction is represented by electronic screening, already studied by Rabinowitz *et al.*,[3] who determined that the finite dimension r_1 of the nucleons influences the process of fusion within crystalline lattices in a way that can be represented schematically supposing the electric charge to be distributed uniformly on the inside of a thin spherical shell with radius $R \geq r_1$ equal to the effective range of the interaction between nucleons, which can be described in terms of a shifted Coulomb potential:[3]

$$V = \left(kq^2\right)\left[1/r - 1/R\right] \qquad r_1 \leq r \leq R \qquad (4)$$

where $k = {}^1/_4\, \pi\, \varepsilon_0$. The solution for the semi-classic factor of penetration of the potential barrier is given by:

$$\Lambda = D \exp\left[-2\gamma\left(r_1\right)\right] \qquad (5)$$

In (5), the function γ is proportional to the electric charge of the nucleons and to the square root of the product μr_2, where μ is the reduced mass of the center of mass system for an interaction of two bodies and r_2 the classic point of inversion.

In this section we assume that the potential (4) can describe the effect of the impurities present in the metal if the constant D is modified in the product $J\eta$, where J is the concentration of impurities and $\eta \simeq 1$, a numerical constant.

Interaction in the three-dimensional model, instead, is described by a potential $V(r)_{int}$ of the type:

$$V(r)_{int} = k\frac{q^2}{r}\cdot\left[V(r)_M - \frac{\xi\,\hbar\omega\,R}{r}\right] \qquad (6)$$

where $k = {}^1/_4\, \pi\, \varepsilon_0$, q the deuteron charge, ω the pulsation of deuterons in the metal, R the nuclear radius, ξ a parameter varying between 0.015 and 0.025 which depends on the structural characteristics of the lattice (number of electrons

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in the "d" band and type of lattice symmetry). $V_M(r)$ is the Morse potential,[2] modified as follows:

$$V_M(r) = (J/\varsigma)\left\{\exp\left[-2\varphi(r - r_0)\right] - 2\exp\left[-\varphi(r - r_0)\right]\right\} \quad (7)$$

The results obtained for the probability of fusion show that the phenomenon is notably enhanced, in both the "shell" model described by Equation (2) and in the three-dimensional model of Equations (4) and (5), in metals with a concentration of impurities $J \approx 0.72\%$ compared to the case of pure metals ($J \approx 0.28\%$).

Further, fixing the value of J, the probability of fusion in the three-dimensional model is some orders of magnitude greater than in the "shell" model.

Figures 1 and 2 summarize graphically the comparison between the probability of fusion in Pd, Pt, and Ti on varying the energy of the c.m. system, obtained with the models for $J \approx 0.72\%$ and $J \approx 0.28\%$, respectively.

The enhancement effect obtained can be interpreted considering the trend of the potential, which describes the effective interaction between deuterons within the metal. In effect this shows that the coupling between plasmons and deuterons, in the presence of impurities, is able not only to reduce the thickness but also lower the height of the Coulomb barrier K in various types of deuterium-loaded lattices.

In fact, in the case of the metal pure to approximately 0.28%, this barrier is very high. To cross it, therefore, would require a total energy greater than the potential (Figure 2).

For metals with a concentration of impurities of approximately 0.72%, under the same dynamic conditions, the probability of fusion is higher than in the case of pure metals, with a lower total energy of potential, thus increasing the tunneling effect (Figure 1). Figure 3 shows a comparison between the different trends.[2]

The effect of "enhancing" the probability of fusion within deuterium-loaded metal lattices compared to the "free" process differs for different metals due to their different structural characteristics: palladium and platinum have respectively ten and nine "d" band electrons and cubic symmetry, nickel has cubic symmetry but only eight "d" electrons.

In this section, we have considered an overall view of the influences which different concentrations of impurities present in the lattice can have on the phenomenon of deuteron catalyzed fusion.

The numerical calculation performed for Pd, Pt, and Ni at fixed lattice temperature, as a function of the concentration of impurities at 0.28% and 0.72%, shows that the probability of penetration of the Coulomb barrier increases on increasing the impurity. This result can be interpreted considering the trend of the potential which describes the effective interaction between the deuterons within the metal. In effect it shows that in the presence of impurities plasmon-deuteron coupling is able to not only reduce the thickness but also lower the height of the Coulomb barrier K in various types of deuterium-loaded lattices. In fact, in the case of the metal pure to approximately 0.28% circa, this barrier is very high. To cross it, therefore, would require a total energy greater than the potential, as represented in Figure 2.

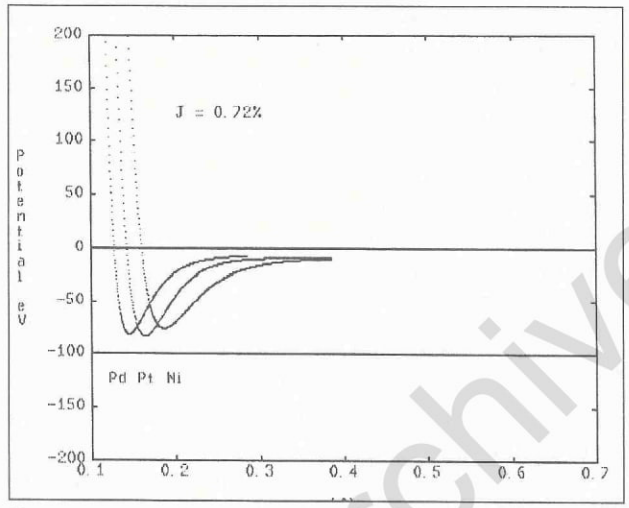

Figure 1. The phenomenon of tunneling appears enhanced for metals with $J \approx 0.72\%$.

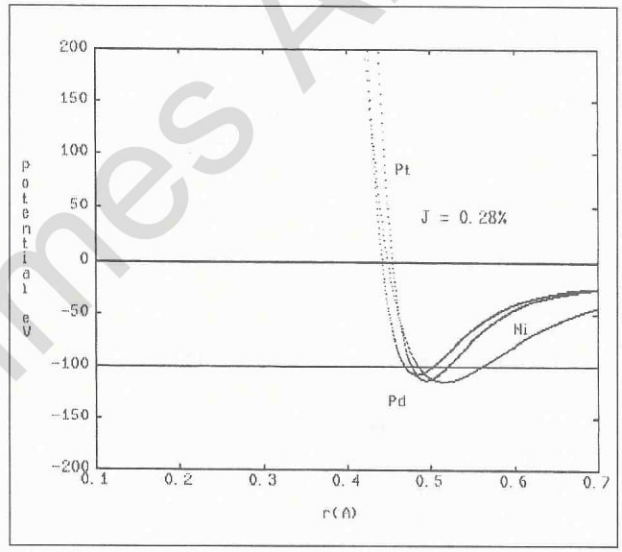

Figure 2. The Coulomb barrier appears very high in the case of pure metals with $J \approx 0.28\%$. To cross it, therefore, requires a total energy greater than the potential itself.

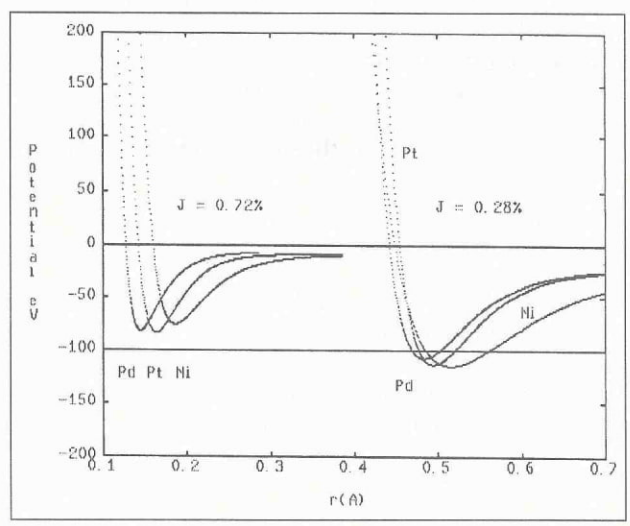

Figure 3. Figures 1 and 2 combined to evidence the different trends of the Coulomb potentials.

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III. Three-Dimensional Model at Energy ≠ Constant and Variable Temperature

In this section we wish to determine if, and within which limits, the phenomenon of deuteron-plasmon interaction within a cubic lattice can be conditioned or influenced by any "micro-deformations" produced in the crystalline lattice on varying the temperature. In Section II we analyzed a three-dimensional model with CFC symmetry with micro-deformations resulting from variations in temperature within the range 36.7° – 63.7°K. We have also presented a theoretical study of the trend shown by the curve of deuteron-plasmon interaction potential within a palladium lattice, from which it appears that the thickness of the Coulomb barrier is reduced on varying the total energy and the concentration of impurities present in the metal.

In this section, our aim is to study again any possible enhancement of the tunnelling effect by calculating this within a microcrack. Further, we will examine whether the height of the Coulomb barrier depends on the parameters[1] T and E.

Taking the center of mass as the reference system, the probability of fusion within a metal can be written as:[1]

$$|P|^2 = \exp\left(-2 \int_0^a K(r)\, dr \right) \tag{8}$$

where a is approximately 0.3 Å and K(r) is given by:

$$K(r) = \sqrt{2\mu[E - V(r)]/\hbar^2} \tag{9}$$

E is the total initial energy, principally thermal in nature, in eV, $\hbar$ is Planck's constant, μ is the reduced mass of the deuterons.

Equations (8) and (9) refer to the process of fusion within the crystalline lattice and contain all the relevant information from the physics point of view as long as we have an explicit form for the potential of interaction $V(r)$, which takes account of the principle effects influencing the phenomenon. With the aim of accounting for the mechanism described in the introduction, the formation of microcracks induced by variations in temperature, Equations (4) and (5) can be appropriately modified by introducing a term kT of thermal energy. The interaction potential is further extended to include the case of a three-dimensional isotope.

The potential $V(r)$ can thus be expressed as follows:

$$V(r) = k_0 \frac{q^2}{r} \cdot M_d \left(V(r)_M - \frac{J\, kT\, R}{r} \right) \tag{10}$$

where $k_0 = {}^1/_4\, \pi\, \varepsilon_0$, q is the deuteron charge, M_d the reduced mass of deuterium nuclei, T the absolute temperature at which the metal is placed experimentally, J the concentration of impurities in the crystalline lattice, R the nuclear radius.

The Morse potential in this case will be:

$$V(r)_M = (J/\varsigma) \exp(-2\varphi(r - r_0)) - 2 \exp(-\varphi(r - r_0)) \tag{11}$$

In this equation the parameters ς and φ depend on the dynamic conditions of the system while r_0 is the classic point of inversion.

The trend of the potential is described in Figures 4 and 5, which refer to the Morse contribution and that of electronic screening, respectively (see Equation 4).

Clearly Equations (9-11) are rigorously valid only in the case of spherical symmetry; on the other hand, the conclusions reached through the present analysis should not be strictly dependent on this condition, but remain valid also for lattice structures belonging to a wider class of symmetries. In fact, the mechanism of microcrack formation does not depend on the geometry of the lattice but possesses local characteristics. It is therefore possible to perform a calculation in the case of non-spherical lattices.

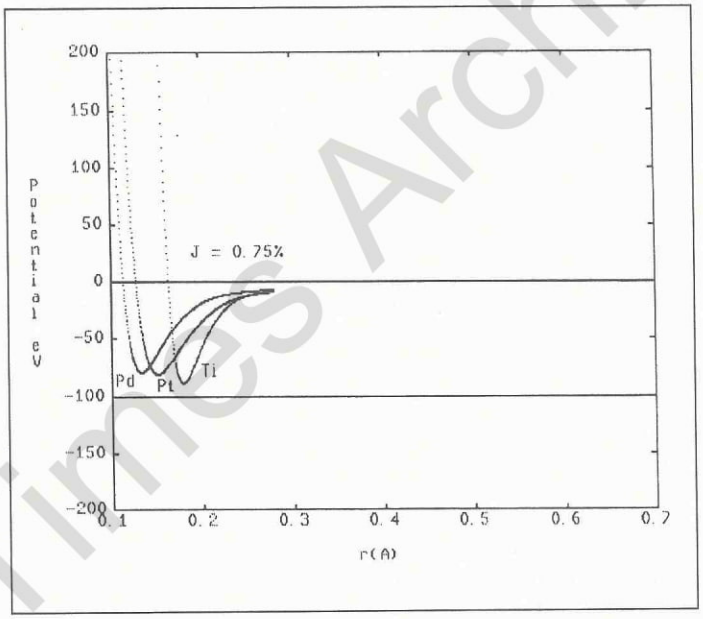

Figure 4. The phenomenon of tunneling appears increased for those metals which have an impurity of $J \approx 0.75\%$. To cross it would require a total energy less than the potential itself. All potentials were calculated at 63.7° K.

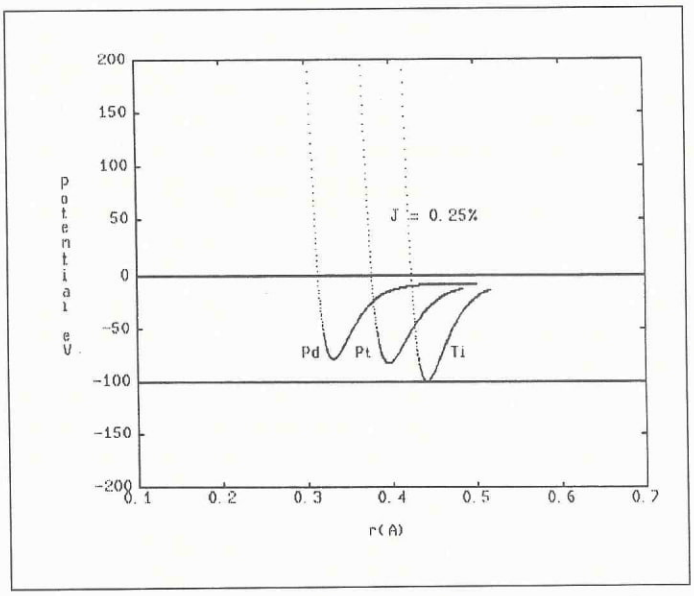

Figure 5. The Coulomb barrier appears very high in the case of pure metals with $J \approx 0.25\%$. To cross it, therefore, would require a total energy greater than the potential itself.

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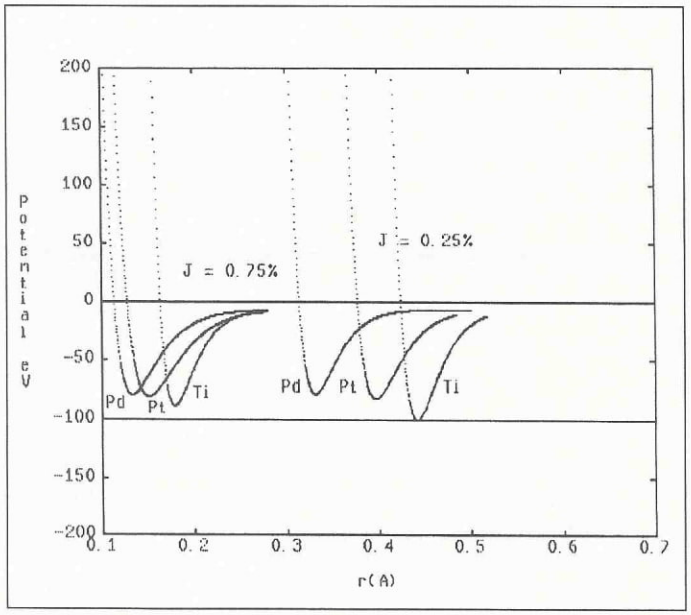

Figure 6. Comparison of the trend of the potentials for $J \approx 0.25\%$ and $J \approx 0.75\%$.

As in Reference 1, in the present analysis we have selected palladium, titanium, and platinum, in order to be able to determine whether the results also depend on specific characteristics of the metals themselves: Pd and Pt have several electrons in the "d" band (ten and nine, respectively) and a CFC lattice, while Ti has only two "d" band electrons and hexagonal symmetry.

On the basis of potentials (4) and (10), the probability of fusion within the lattice was calculated using a numerical simulation program.

The lattice temperature values considered (36.7°K - 63.7°K) were not chosen *a priori* nor at random. Preliminary investigation was conducted over a much wider range, including temperatures below 100° K, in order to determine the interval in which the probability of fusion was dependent on temperature. Point by point analysis was then performed over this interval.

In Figure 4 the lattice temperature is constant at 63.7°K, the highest temperature value for which the vibrational energy contribution can be considered negligible.

In this first approach, the temperature range chosen, considerably lower than typical experimental values (300°K) was dictated by criteria of simplicity; at such low temperatures,

TABLE 1 Pure Metals Palladium

$J \approx 0.28\%$ $\omega \approx 0.13$ Hz $\alpha \approx .37$ Å T(K) = Const		Platinum $J \approx 0.28\%$ $\omega \approx 0.13$ Hz $\alpha \approx .37$ Å T(K) = Const		Nickel $J \approx 0.28\%$ $\omega \approx 0.13$ Hz $\alpha \approx .37$ Å T(K) = Const	
E(eV)		E(eV)		E(eV)	
$E \approx 140$	$P \approx 10^{-81}$	$E \approx 140$	$P \approx 10^{-94}$	$E \approx 140$	$P \approx 10^{-100}$
$E \approx 150$	$P \approx 10^{-80}$	$E \approx 150$	$P \approx 10^{-92}$	$E \approx 150$	$P \approx 10^{-98}$
$E \approx 160$	$P \approx 10^{-79}$	$E \approx 160$	$P \approx 10^{-90}$	$E \approx 160$	$P \approx 10^{-97}$
$E \approx 170$	$P \approx 10^{-78}$	$E \approx 170$	$P \approx 10^{-87}$	$E \approx 170$	$P \approx 10^{-95}$
$E \approx 180$	$P \approx 10^{-76}$	$E \approx 180$	$P \approx 10^{-86}$	$E \approx 180$	$P \approx 10^{-92}$
$E \approx 190$	$P \approx 10^{-74}$	$E \approx 190$	$P \approx 10^{-85}$	$E \approx 190$	$P \approx 10^{-90}$
$E \approx 200$	$P \approx 10^{-73}$	$E \approx 200$	$P \approx 10^{-84}$	$E \approx 200$	$P \approx 10^{-89}$
$E \approx 210$	$P \approx 10^{-72}$	$E \approx 210$	$P \approx 10^{-82}$	$E \approx 210$	$P \approx 10^{-80}$
$E \approx 220$	$P \approx 10^{-70}$	$E \approx 220$	$P \approx 10^{-80}$	$E \approx 220$	$P \approx 10^{-79}$
$E \approx 230$	$P \approx 10^{-68}$	$E \approx 230$	$P \approx 10^{-78}$	$E \approx 230$	$P \approx 10^{-77}$
$E \approx 240$	$P \approx 10^{-65}$	$E \approx 240$	$P \approx 10^{-76}$	$E \approx 240$	$P \approx 10^{-74}$
$E \approx 250$	$P \approx 10^{-64}$	$E \approx 250$	$P \approx 10^{-75}$	$E \approx 250$	$P \approx 10^{-71}$

TABLE 2 Impure Metals Palladium

$J \approx 0.72\%$ $\omega \approx 0.13$ Hz $\alpha \approx .37$ Å T(K) = Const		Platinum $J \approx 0.72\%$ $\omega \approx 0.13$ Hz $\alpha \approx .37$ Å T(K) = Const		Nickel $J \approx 0.72\%$ $\omega \approx 0.13$ Hz $\alpha \approx .37$ Å T(K) = Const	
E(eV)		E(eV)		E(eV)	
$E \approx 140$	$P \approx 10^{-84}$	$E \approx 140$	$P \approx 10^{-86}$	$E \approx 140$	$P \approx 10^{-90}$
$E \approx 150$	$P \approx 10^{-81}$	$E \approx 150$	$P \approx 10^{-84}$	$E \approx 150$	$P \approx 10^{-86}$
$E \approx 160$	$P \approx 10^{-79}$	$E \approx 160$	$P \approx 10^{-83}$	$E \approx 160$	$P \approx 10^{-83}$
$E \approx 170$	$P \approx 10^{-75}$	$E \approx 170$	$P \approx 10^{-80}$	$E \approx 170$	$P \approx 10^{-80}$
$E \approx 180$	$P \approx 10^{-73}$	$E \approx 180$	$P \approx 10^{-78}$	$E \approx 180$	$P \approx 10^{-78}$
$E \approx 190$	$P \approx 10^{-71}$	$E \approx 190$	$P \approx 10^{-76}$	$E \approx 190$	$P \approx 10^{-75}$
$E \approx 200$	$P \approx 10^{-70}$	$E \approx 200$	$P \approx 10^{-74}$	$E \approx 200$	$P \approx 10^{-74}$
$E \approx 210$	$P \approx 10^{-68}$	$E \approx 210$	$P \approx 10^{-72}$	$E \approx 210$	$P \approx 10^{-72}$
$E \approx 220$	$P \approx 10^{-65}$	$E \approx 220$	$P \approx 10^{-70}$	$E \approx 220$	$P \approx 10^{-70}$
$E \approx 230$	$P \approx 10^{-63}$	$E \approx 230$	$P \approx 10^{-67}$	$E \approx 230$	$P \approx 10^{-69}$
$E \approx 240$	$P \approx 10^{-62}$	$E \approx 240$	$P \approx 10^{-66}$	$E \approx 240$	$P \approx 10^{-68}$
$E \approx 250$	$P \approx 10^{-60}$	$E \approx 250$	$P \approx 10^{-63}$	$E \approx 250$	$P \approx 10^{-64}$

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Table 3a.

Palladium T ≈ 36.7 K			
E(eV)	P	E(eV)	P
≈ 140	$\approx 10^{-60}$	≈ 150	$\approx 10^{-55}$
≈ 160	$\approx 10^{-52}$	≈ 170	$\approx 10^{-47}$
≈ 180	$\approx 10^{-45}$	≈ 190	$\approx 10^{-43}$
≈ 200	$\approx 10^{-42}$	≈ 210	$\approx 10^{-41}$
≈ 220	$\approx 10^{-40}$	≈ 230	$\approx 10^{-39}$
≈ 240	$\approx 10^{-37}$	≈ 250	$\approx 10^{-35}$
T ≈ 45.7 K E(eV)	P	E(eV)	P
≈ 140	$\approx 10^{-59}$	≈ 150	$\approx 10^{-54}$
≈160	$\approx 10^{-50}$	≈ 170	$\approx 10^{-44}$
≈ 180	$\approx 10^{-42}$	≈ 190	$\approx 10^{-40}$
≈ 200	$\approx 10^{-39}$	≈ 210	$\approx 10^{-38}$
≈ 220	$\approx 10^{-37}$	≈ 230	$\approx 10^{-36}$
≈ 240	$\approx 10^{-35}$	≈ 250	$\approx 10^{-33}$
T ≈ 54.7 K E(eV)	P	E(eV)	P
≈ 140	$\approx 10^{-61}$	≈ 150	$\approx 10^{-58}$
≈ 160	$\approx 10^{-57}$	≈ 170	$\approx 10^{-53}$
≈ 180	$\approx 10^{-48}$	≈ 190	$\approx 10^{-44}$
≈ 200	$\approx 10^{-54}$	≈ 210	$\approx 10^{-46}$
≈ 220	$\approx 10^{-42}$	≈ 230	$\approx 10^{-35}$
≈ 240	$\approx 10^{-30}$	≈ 250	$\approx 10^{-26}$
T ≈ 63.7 K E(eV)	P	E(eV)	P
≈ 140	$\approx 10^{-67}$	≈ 150	$\approx 10^{-65}$
≈ 160	$\approx 10^{-62}$	≈ 170	$\approx 10^{-59}$
≈ 180	$\approx 10^{-55}$	≈ 190	$\approx 10^{-50}$
≈ 200	$\approx 10^{-44}$	≈ 210	$\approx 10^{-38}$
≈ 220	$\approx 10^{-35}$	≈ 230	$\approx 10^{-31}$
≈ 240	$\approx 10^{-28}$	≈ 250	$\approx 10^{-25}$

Table 3b.

Platinum T ≈ 36.7 K			
E(eV)	P	E(eV)	P
≈ 140	$\approx 10^{-89}$	≈ 150	$\approx 10^{-84}$
≈ 160	$\approx 10^{-81}$	≈ 170	$\approx 10^{-79}$
≈ 180	$\approx 10^{-77}$	≈ 190	$\approx 10^{-76}$
≈ 200	$\approx 10^{-74}$	≈ 210	$\approx 10^{-73}$
≈ 220	$\approx 10^{-72}$	≈ 230	$\approx 10^{-71}$
≈ 240	$\approx 10^{-70}$	≈ 250	$\approx 10^{-69}$
T ≈ 45.7 K E(eV)	P	E(eV)	P
≈ 140	$\approx 10^{-87}$	≈ 150	$\approx 10^{-85}$
≈ 160	$\approx 10^{-82}$	≈ 170	$\approx 10^{-79}$
≈ 180	$\approx 10^{-78}$	≈ 190	$\approx 10^{-75}$
≈ 200	$\approx 10^{-73}$	≈ 210	$\approx 10^{-72}$
≈ 220	$\approx 10^{-71}$	≈ 230	$\approx 10^{-70}$
≈ 240	$\approx 10^{-69}$	≈ 250	$\approx 10^{-68}$
T ≈ 54.7 K E(eV)	P	E(eV)	P
≈140	$\approx 10^{-95}$	≈ 150	$\approx 10^{-93}$
≈160	$\approx 10^{-89}$	≈ 170	$\approx 10^{-86}$
≈180	$\approx 10^{-83}$	≈ 190	$\approx 10^{-79}$
≈ 200	$\approx 10^{-74}$	≈ 210	$\approx 10^{-71}$
≈ 220	$\approx 10^{-67}$	≈ 230	$\approx 10^{-65}$
≈ 240	$\approx 10^{-63}$	≈ 250	$\approx 10^{-62}$
T ≈ 63.7 K E(eV)	P	E(eV)	P
≈ 140	$\approx 10^{-90}$	≈ 150	$\approx 10^{-88}$
≈ 160	$\approx 10^{-85}$	≈ 170	$\approx 10^{-83}$
≈ 180	$\approx 10^{-79}$	≈ 190	$\approx 10^{-76}$
≈ 200	$\approx 10^{-73}$	≈ 210	$\approx 10^{-69}$
≈ 220	$\approx 10^{-66}$	≈ 230	$\approx 10^{-64}$
≈ 240	$\approx 10^{-63}$	≈ 250	$\approx 10^{-60}$

Tables 3a, 3b, 3c. Probability of fusion for *impure metals*, with $J = 0.75\%$, $\alpha \approx 0.24$ Å, for different values of temperature (36.7°K - 63.7°K) and energy (140 eV - 250 eV). It can be seen that the probability generally increases both on increasing *T* and on increasing *E*. Further, the maximum probability values are those of palladium with CFC symmetry.

the vibrational energy transmitted to the deuterons is negligible and can be omitted from the calculation. In any case, the mechanism studied here may be slow but must not be considered *ipso facto* inefficient. It is, however, clear that an analysis closer to experimental reality must also take account of those effects, which it is possible to ignore here.

For very low values of T, $P \propto T$. Further, of the three metals considered, Ti shows the lowest probability of fusion, probably because this element has only two "d" band electrons, unlike Pd and Pt.

As can be seen comparing Figures 4 and 5 (Figure 6), potential (10) determines a lower barrier: this corresponds to the results obtained showing a higher probability of fusion.

This enhancing effect, linked to the particularity of potential (10), although not yet sufficient to account for the experimental results of Pons and Fleischmann,[5] nevertheless appears an interesting step towards a full theoretical understanding of the phenomenon of cold fusion. Naturally, the interpretation of the effect found here cannot be considered defined in all aspects; as evidenced above, there is a difference of some 6 - 7 orders of magnitude between *E* and the term *kT* not fully covered by the effects of the chain reaction hypothesized.

For a more complete physical explanation of the effect described here, a more rigorous examination of microcrack formation is currently in progress. Further, we are attempting to extend the range of temperatures up to room temperature, taking account of the vibrational energy.

We are also conducting a study of the trend of potentials (4) and (10) at temperatures varying from 100°K to 300°K. To give an idea of the preliminary results already obtained, with the dynamic conditions of the three impure metals fixed as:

$$\alpha \approx .11 \text{ Å}$$
$$E \approx 243.16 \text{ eV}$$
$$J \approx 0.75\%$$
$$T \approx 250^\circ\text{K}$$

The probability of fusion obtained for palladium is $P_{pd} \approx 10^{-61}$, and for platinum $P_{pt} \approx 10^{-90}$. In the case of titanium, for the approximations used and under the same conditions, there is a much lower probability of fusion $P_{ti} \approx 10^{-110}$.

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Table 3c.

Titanium T ≈ 36.7 K			
E(eV)	P	E(eV)	P
≈ 140	≈ 10^{-99}	≈ 150	≈ 10^{-98}
≈ 160	≈ 10^{-97}	≈ 170	≈ 10^{-96}
≈ 180	≈ 10^{-95}	≈ 190	≈ 10^{-94}
≈ 200	≈ 10^{-93}	≈ 210	≈ 10^{-92}
≈ 220	≈ 10^{-91}	≈ 230	≈ 10^{-90}
≈ 240	≈ 10^{-88}	≈ 250	≈ 10^{-85}
T ≈ 45.7 K E(eV)	P	E(eV)	P
≈ 140	≈ 10^{-97}	≈ 150	≈ 10^{-95}
≈ 160	≈ 10^{-94}	≈ 170	≈ 10^{-93}
≈ 180	≈ 10^{-92}	≈ 190	≈ 10^{-90}
≈ 200	≈ 10^{-88}	≈ 210	≈ 10^{-86}
≈ 220	≈ 10^{-85}	≈ 230	≈ 10^{-84}
≈ 240	≈ 10^{-83}	≈ 250	≈ 10^{-80}
T ≈ 54.7 K E(eV)	P	E(eV)	P
≈ 140	≈ 10^{-86}	≈ 150	≈ 10^{-85}
≈ 160	≈ 10^{-84}	≈ 170	≈ 10^{-83}
≈ 180	≈ 10^{-82}	≈ 190	≈ 10^{-81}
≈ 200	≈ 10^{-79}	≈ 210	≈ 10^{-77}
≈ 220	≈ 10^{-75}	≈ 230	≈ 10^{-74}
≈ 240	≈ 10^{-73}	≈ 250	≈ 10^{-71}
T ≈ 63.7 K E(eV)	P	E(eV)	P
≈ 140	≈ 10^{-84}	≈ 150	≈ 10^{-81}
≈ 160	≈ 10^{-79}	≈ 170	≈ 10^{-75}
≈ 180	≈ 10^{-74}	≈ 190	≈ 10^{-73}
≈ 200	≈ 10^{-72}	≈ 210	≈ 10^{-69}
≈ 220	≈ 10^{-65}	≈ 230	≈ 10^{-64}
≈ 240	≈ 10^{-63}	≈ 250	≈ 10^{-61}

Table 4a.

Palladium T ≈ 36.7 K			
E(eV)	P	E(eV)	P
≈ 140	≈ 10^{-85}	≈ 150	≈ 10^{-83}
≈ 160	≈ 10^{-81}	≈ 170	≈ 10^{-80}
≈ 180	≈ 10^{-79}	≈ 190	≈ 10^{-78}
≈ 200	≈ 10^{-76}	≈ 210	≈ 10^{-75}
≈ 220	≈ 10^{-74}	≈ 230	≈ 10^{-73}
≈ 240	≈ 10^{-72}	≈ 250	≈ 10^{-71}
T ≈ 45.7 K E(eV)	P	E(eV)	P
≈ 140	≈10^{-90}	≈150	≈10^{-88}
≈ 160	≈10^{-87}	≈170	≈10^{-86}
≈ 180	≈10^{-85}	≈190	≈10^{-84}
≈ 200	≈10^{-83}	≈210	≈10^{-82}
≈ 220	≈10^{-81}	≈230	≈10^{-80}
≈ 240	≈10^{-79}	≈250	≈10^{-78}
T ≈ 54.7 K E(eV)	P	E(eV)	P
≈140	≈10^{-92}	≈150	≈10^{-90}
≈160	≈10^{-89}	≈170	≈10^{-88}
≈180	≈10^{-85}	≈190	≈10^{-84}
≈200	≈10^{-83}	≈210	≈10^{-82}
≈220	≈10^{-81}	≈230	≈10^{-80}
≈240	≈10^{-78}	≈250	≈10^{-74}
T ≈ 63.7 K E(eV)	P	E(eV)	P
≈140	≈10^{-87}	≈150	≈10^{-86}
≈160	≈10^{-85}	≈170	≈10^{-84}
≈180	≈10^{-83}	≈190	≈10^{-82}
≈200	≈10^{-80}	≈210	≈10^{-79}
≈220	≈10^{-78}	≈230	≈10^{-75}
≈240	≈10^{-73}	≈250	≈10^{-70}

IV. Conclusions

This paper presents a summarized study of the effects different concentrations of impurities and variations in energy and temperature can have on the phenomenon of deuteron fusion catalyzed by lattice plasmons.

At constant lattice temperature, the numerical calculation conducted for Pd, Pt, and Ni as a function of the concentration of impurities, varying from $J \approx 0.28\%$ to $J \approx 0.72\%$, shows that the probability of penetration of the Coulomb barrier increases with decreasing J. This result can be interpreted considering the trend of the potential describing the effective interaction between deuterons within the metal. In effect it shows that in the presence of impurities, plasmon-deuteron coupling is able to both reduce the thickness and lower the height of the Coulomb barrier K in various types of deuterium-loaded lattices.

At variable lattice temperature, instead, the role of the "efficacious" interaction between plasmons and microdefects present in the lattices was found for metals with different concentrations of impurity. The calculation, performed for different metals as a function of the total energy, in turn within certain limits dependent on the temperature, allowed the conclusion that the probability of fusion is enhanced by increasing T and E. Further, of the three metals considered (Pd, Pt, and Ti), palladium seems the most effective in catalyzing fusion due to its structural characteristics; this can be understood in qualitative terms observing that the curve of the interaction potential within the metal has a trend for which a lesser amount of total energy is required (Figures 4 and 5, Tables 3 and 4). If the trends for the interaction potential within the lattice obtained here are compared to the results in Reference 1 and in Section II of the present paper, it can be seen that introducing the effects of temperature in a three-dimensional geometry has important consequences. In fact, the height of the potential barrier is reduced for impure metals ($J \approx 0.75\%$) but remains largely unvaried for pure metals ($J \approx 0.25\%$), or is increased, as in the case of titanium compared to nickel. This implies that in the first case to cross the Coulomb barrier requires a total energy lower than the potential, in this way the tunneling effect could be increased. The probability of fusion within lattices depends on the concentration of impurities present in a typical way: greater probability of fusion is found in impure than in pure metals, confirming the results obtained in Reference 1.

If confirmed by further investigation, this effect would open the way to new theoretical scenarios in which phenomena ignored until now could be deter-

Tables 4a, 4b, 4c. Probability of fusion for *pure metals*, with $J = 0.25\%$, $\alpha \approx 0.24$ Å, for different values of temperature (36.7°K - 63.7°K) and energy (140 eV - 250 eV). Under equal dynamic conditions the probability of fusion is notably lower than that of the impure metals of Table. 3. Also here the probability increases both on increasing T and on increasing E, and again the maximum probability values are those of palladium.

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Table 4b.

Platinum T ≈ 36.7 K			
E(eV)	P	E(eV)	P
≈140	≈ 10^{-106}	≈150	≈ 10^{-105}
≈160	≈ 10^{-103}	≈170	≈ 10^{-102}
≈180	≈ 10^{-101}	≈190	≈ 10^{-100}
≈200	≈ 10^{-99}	≈210	≈ 10^{-98}
≈220	≈ 10^{-97}	≈230	≈ 10^{-96}
≈240	≈ 10^{-94}	≈250	≈ 10^{-93}
T ≈ 45.7 K E(eV)	P	E(eV)	P
≈140	≈ 10^{-106}	≈150	≈ 10^{-104}
≈160	≈ 10^{-103}	≈170	≈ 10^{-102}
≈180	≈ 10^{-101}	≈190	≈ 10^{-99}
≈200	≈ 10^{-98}	≈210	≈ 10^{-97}
≈220	≈ 10^{-95}	≈230	≈ 10^{-94}
≈240	≈ 10^{-91}	≈250	≈ 10^{-89}
T ≈ 54.7 K E(eV)	P	E(eV)	P
≈140	≈ 10^{-98}	≈150	≈ 10^{-94}
≈160	≈ 10^{-92}	≈170	≈ 10^{-90}
≈180	≈ 10^{-87}	≈190	≈ 10^{-86}
≈200	≈ 10^{-85}	≈210	≈ 10^{-84}
≈220	≈ 10^{-83}	≈230	≈ 10^{-82}
≈240	≈ 10^{-81}	≈250	≈ 10^{-80}
T ≈ 63.7 K E(eV)	P	E(eV)	P
≈140	≈ 10^{-93}	≈ 150	≈ 10^{-92}
≈160	≈ 10^{-91}	≈ 170	≈ 10^{-89}
≈180	≈ 10^{-86}	≈ 190	≈ 10^{-85}
≈200	≈ 10^{-84}	≈ 210	≈ 10^{-83}
≈220	≈ 10^{-80}	≈ 230	≈ 10^{-76}
≈240	≈ 10^{-75}	≈ 250	≈ 10^{-73}

Table 4c.

Titanium T ≈ 36.7 K			
E(eV)	P	E(eV)	P
≈140	≈ 10^{-109}	≈ 150	≈ 10^{-108}
≈160	≈ 10^{-107}	≈ 170	≈ 10^{-106}
≈180	≈ 10^{-105}	≈ 190	≈ 10^{-103}
≈200	≈ 10^{-102}	≈ 210	≈ 10^{-101}
≈220	≈ 10^{-100}	≈ 230	≈ 10^{-99}
≈240	≈ 10^{-98}	≈ 250	≈ 10^{-97}
T ≈ 45.7 K E(eV)	P	E(eV)	P
≈140	≈ 10^{-111}	≈150	≈ 10^{-107}
≈160	≈ 10^{-105}	≈170	≈ 10^{-104}
≈180	≈ 10^{-102}	≈190	≈ 10^{-100}
≈200	≈ 10^{-99}	≈210	≈ 10^{-98}
≈220	≈ 10^{-97}	≈230	≈ 10^{-95}
≈240	≈ 10^{-94}	≈250	≈ 10^{-92}
T ≈ 54.7 K E(eV)	P	E(eV)	P
≈140	≈ 10^{-105}	≈ 150	≈ 10^{-104}
≈160	≈ 10^{-103}	≈ 170	≈ 10^{-100}
≈180	≈ 10^{-97}	≈ 190	≈ 10^{-96}
≈200	≈ 10^{-94}	≈ 210	≈ 10^{-93}
≈220	≈ 10^{-92}	≈ 230	≈ 10^{-91}
≈240	≈ 10^{-89}	≈ 250	≈ 10^{-87}
T ≈ 63.7 K E(eV)	P	E(eV)	P
≈140	≈ 10^{-99}	≈150	≈ 10^{-98}
≈160	≈ 10^{-97}	≈170	≈ 10^{-96}
≈180	≈ 10^{-95}	≈190	≈ 10^{-94}
≈200	≈ 10^{-93}	≈210	≈ 10^{-92}
≈220	≈ 10^{-90}	≈230	≈ 10^{-89}
≈240	≈ 10^{-87}	≈250	≈ 10^{-86}

mining for a wider understanding of the mechanisms underlying cold fusion. One of these mechanisms, essentially consisting of a kind of chain reaction between deuterons present within the metal lattice, catalyzed by microcracks produced in the structure by variations in the thermodynamic conditions or for other motives, is hypothesized here and constitutes our principle theoretical argument.

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About the Author

Mr. Frisone is a researcher in the Department of Physics at the University of Catania (Sicily, Italy). His interests are in cold fusion and the collective effects of temperature within lattices, as well as chaos, thermodynamic conditions, and the tunneling effect.

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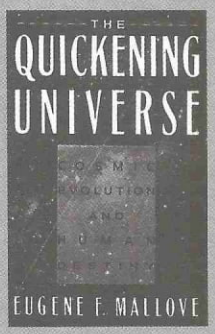

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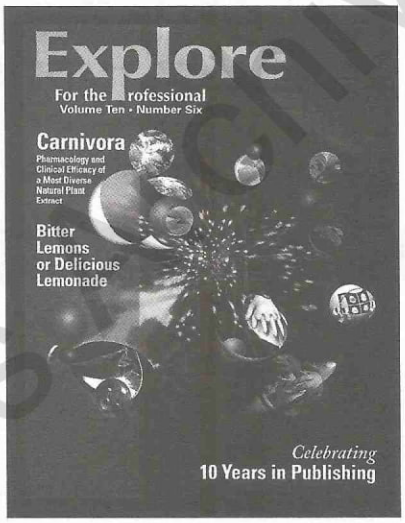

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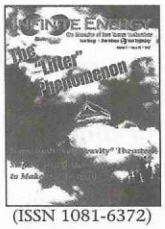

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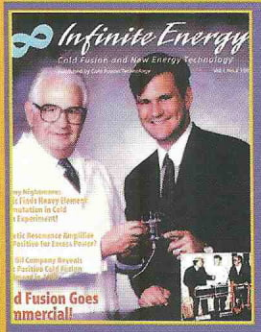

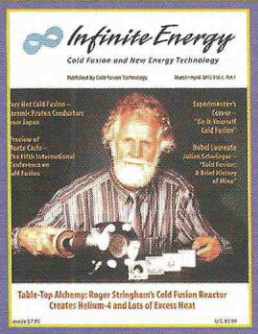

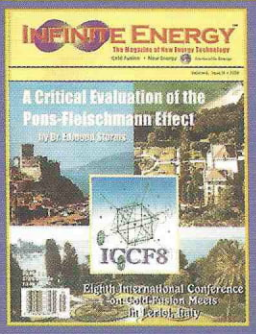

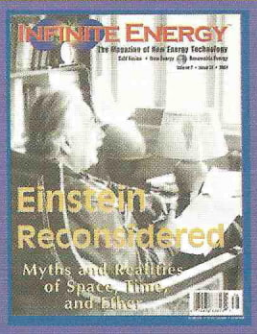

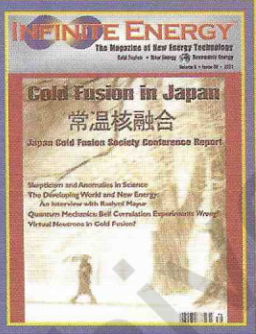

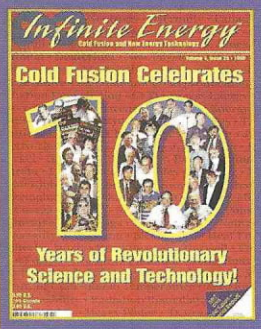

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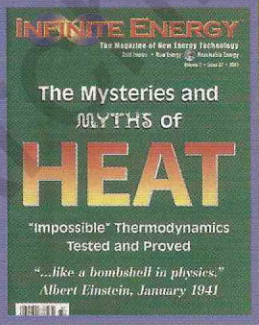

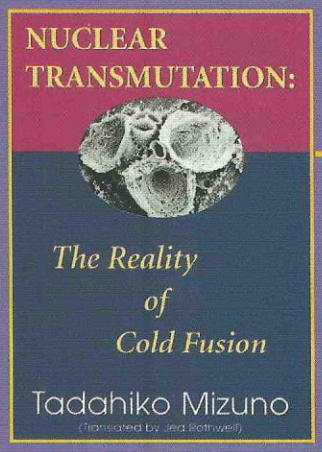

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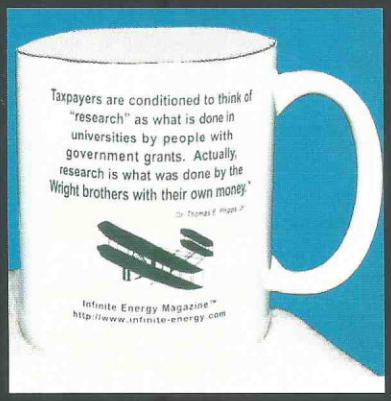

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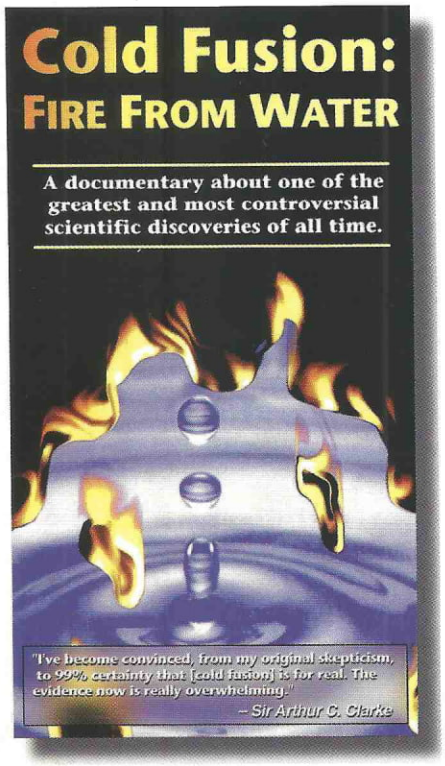

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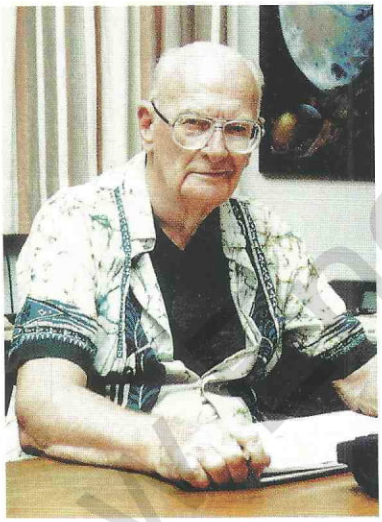

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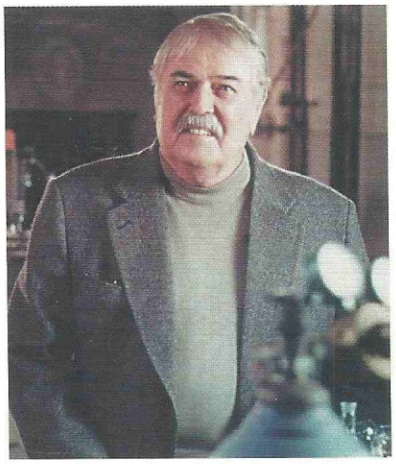

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